Assessment of Pacific cod in the Aleutian Islands

NOAA FISHERIES
Alaska Fisheries Science Center

Grant Thompson and Wayne Palsson

November 18, 2014

Team and SSC comments

Comments on assessments in general (1 of 3)

- JPT1 (9/13 minutes): *"The Teams recommended that SAFE chapter authors continue to include 'other' removals as an appendix. Optionally, authors could also calculate the impact of these removals on reference points and specifications, but are not required to include such calculations in final recommendations for OFL and ABC."* "Other" removals are presented in Appendix 2A.2
- JPT2 (9/13 minutes): *"In conformity with the main recommendations of the working group, the Teams recommended the following:*
  1. *Assessment authors should routinely do retrospective analyses extending back 10 years, plot spawning biomass estimates and error bars, plot relative differences, and report Mohn's rho (revised).*
  2. *If a model exhibits a retrospective pattern, try to investigate possible causes.*
  3. *Communicate the uncertainty implied by retrospective variability in biomass estimates.*
  4. *For the time being, do not disqualify a model on the grounds of poor retrospective performance alone.*
  5. *Do consider retrospective performance as one factor in model selection."*

  See "Results" section, under "Model Evaluation" and also a new subsection entitled "Retrospective Analysis," located under "Time Series Results"

Comments on assessments in general (2 of 3)

- JPT3 (9/13 minutes): *"The Teams recommended that each stock assessment model incorporate the best possible estimate of the current year's removals. The Teams plan to inventory how their respective authors address and calculate total current year removals. Following analysis of this inventory, the Teams will provide advice to authors on the appropriate methodology for calculating current year removals to ensure consistency across assessments and FMPs."* This comment is addressed under the "Standard Harvest Scenarios, Projection Methodology, and Projection Results" subsection of the "Results" section
- SSC1 (10/13 minutes): *"We agree with the recommendations of the Plan Team that retrospective analyses extending back 10 years and including Mohn's revised ρ, should routinely be presented in the assessments, and that retrospective patterns should be taken into consideration when selecting a model and when communicating uncertainties associated with biomass estimates. The SSC also notes that a strong retrospective bias should be one of the criteria considered when setting ABCs and could provide justification for recommending a higher or lower ABC."* See response to comment JPT2; also, consideration of retrospective bias in the context of ABC is addressed in the "Harvest Recommendations" subsection of the "Results" section

Comments on assessments in general (3 of 3)

- SSC2 (12/13): *"During public testimony, it was proposed that assessment authors should consider projecting the reference points for the future two years (e.g., 2014 and 2015) on the phase diagrams. It was suggested that this forecast would be useful to the public. The SSC agrees. The SSC appreciated this suggestion and asks the assessment authors to do so in the next assessment."* Figure 2A.17 includes projected values for the next two years.
- JPT4 (9/14): Regarding catch projections, *"the Teams recommend that authors choose a method that appears to be appropriate for their stock, and this method be clearly documented. The Teams recommend authors establish their best available estimate of catch in the current year and the next two years. The Teams recommend that authors should also document how those projected catches were determined in the Harvest Recommendations section (ideally Scenario 2)."* See response to comment JPT3; also, estimation of projected catches is addressed in the same subsection, and those estimated catches are used in Scenario 2
- SSC3 (10/14): Regarding comment JPT4, *"The SSC supports these recommendations."* See response to comments JPT3 and JPT4

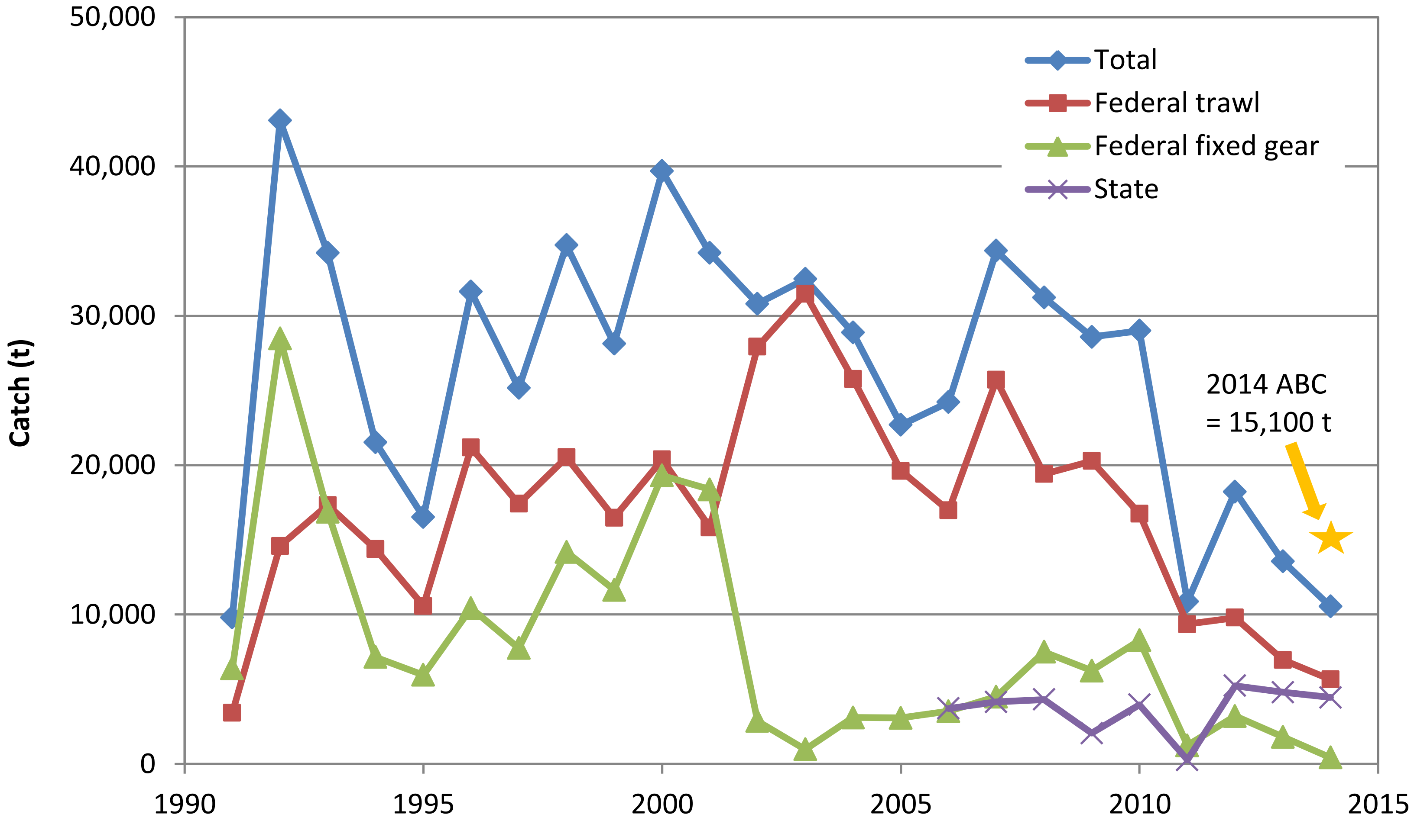
Comments on this assessment

- 11 comments addressed in preliminary assessment; not repeated here
- BPT1 (9/14): *"For November, the Team recommends that Grant supply three candidate models, all based on data from 1991 onward, which means that there is no need to estimate a recruitment offset (because the data do not span an environmental regime shift):*
  1. *Model 1 from this meeting (same as Model 2 when the recruitment offset is disregarded).*
  2. *A variant of Model 1 with the priors tightened enough that the survey selectivity schedule is smoother and more like a logistic curve.*
  3. *Tier 5."*

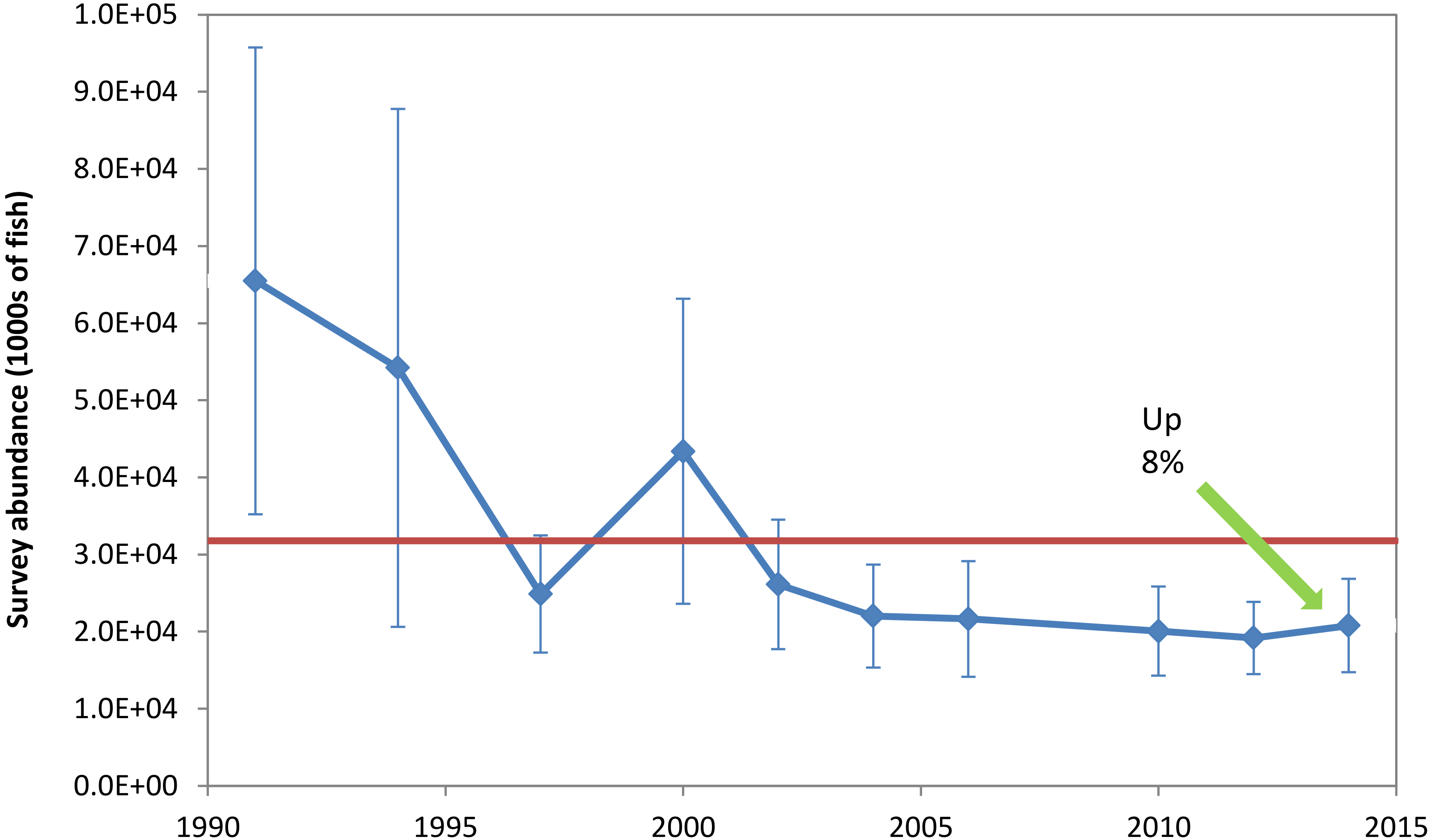
  All of the Team's requested models are included in this assessment, although re-numbered so that last year's model (Tier 5 random effects) is designated Model 1, all based on data from 1991 onward
- SSC4 (10/14): *"The SSC agrees with the Plan Team and recommendations including limiting the data to post-1990 and three candidate models be brought forward to the November plan team meeting."* See response to Comment BPT1. Data are limited to the post-1990 period (see discussion under "Catch Size Composition" in the "Fishery" subsection of the "Data" section)

Data highlights

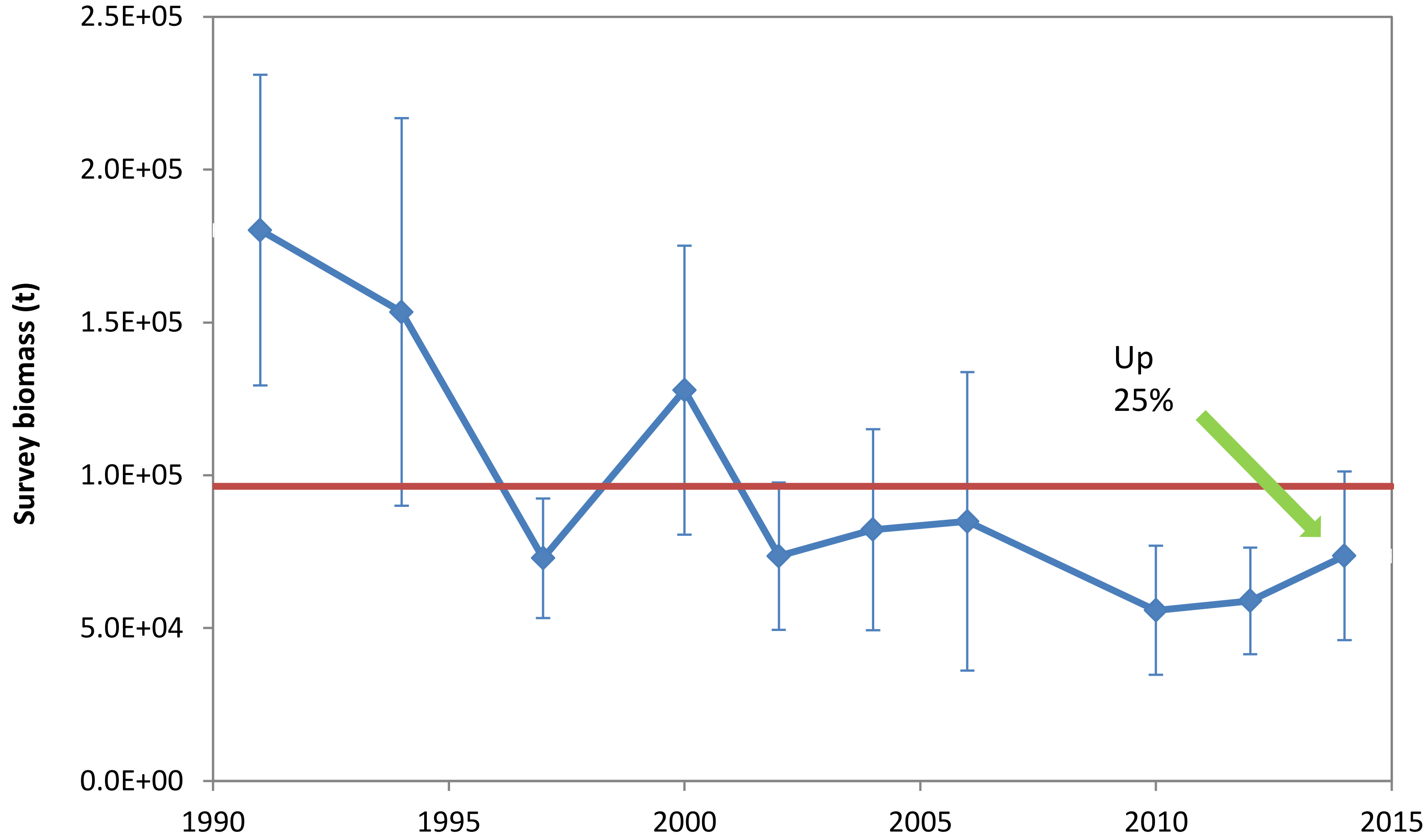
Catch history (2014 data are incomplete)



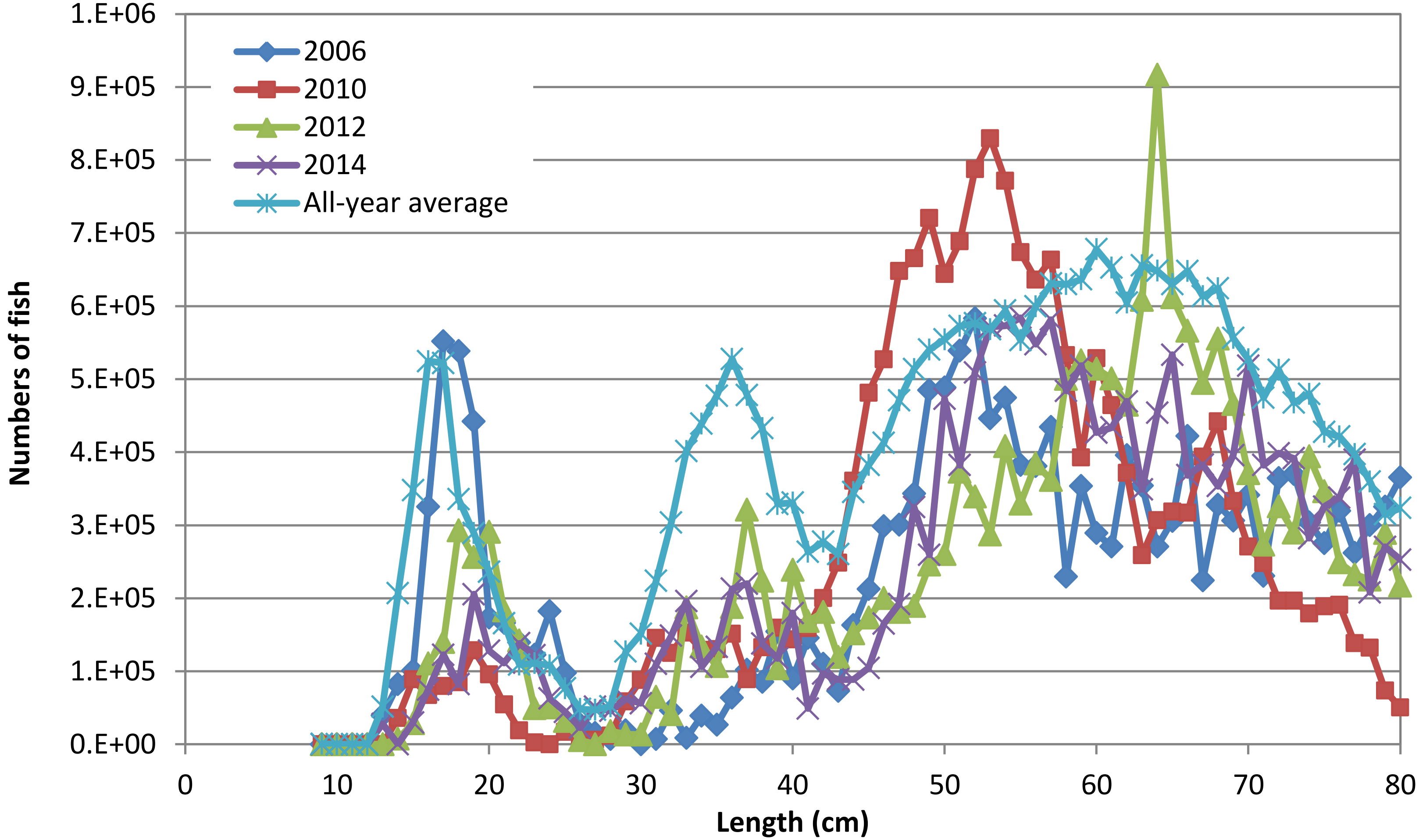
Survey numbers history



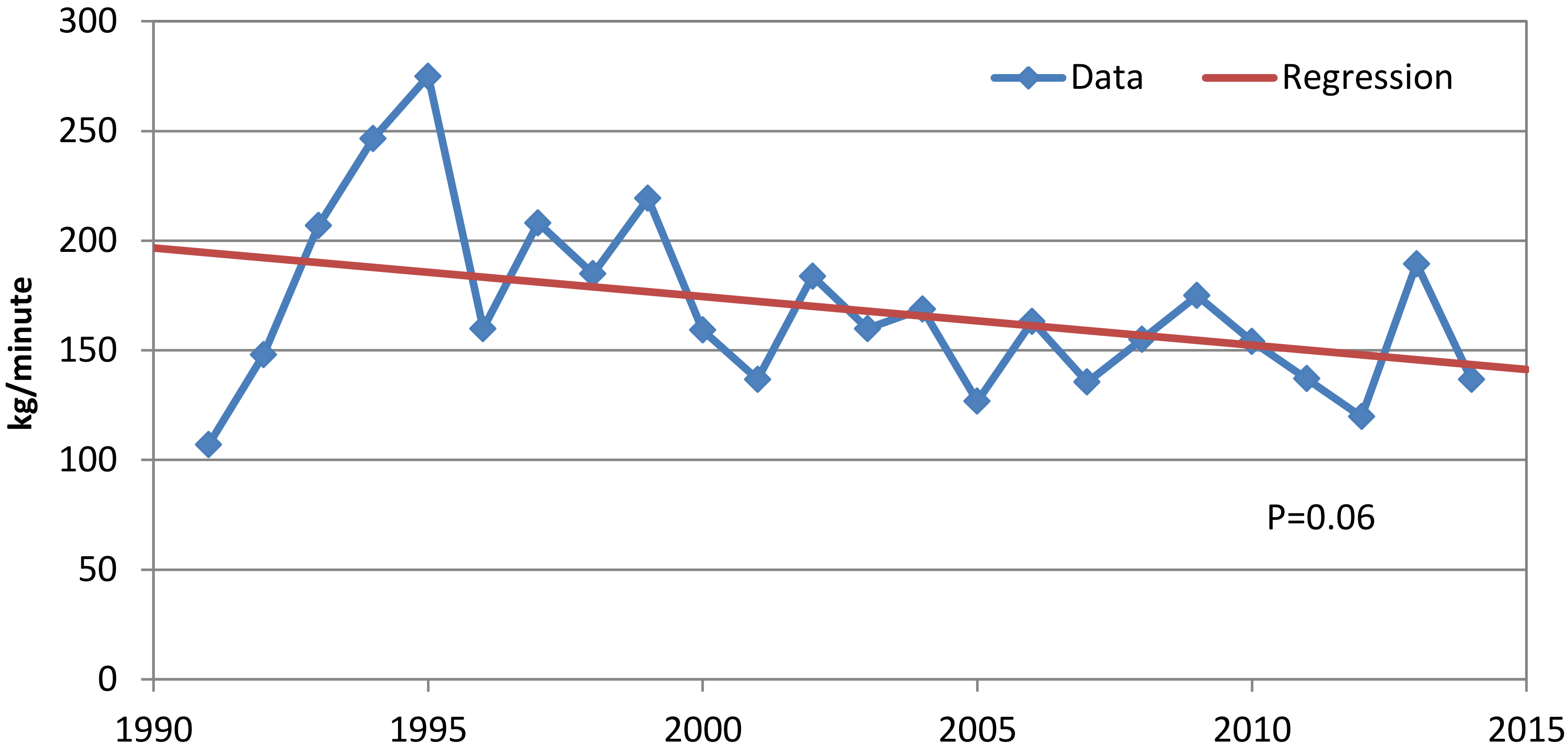
Survey biomass history (not used in M2, M3)



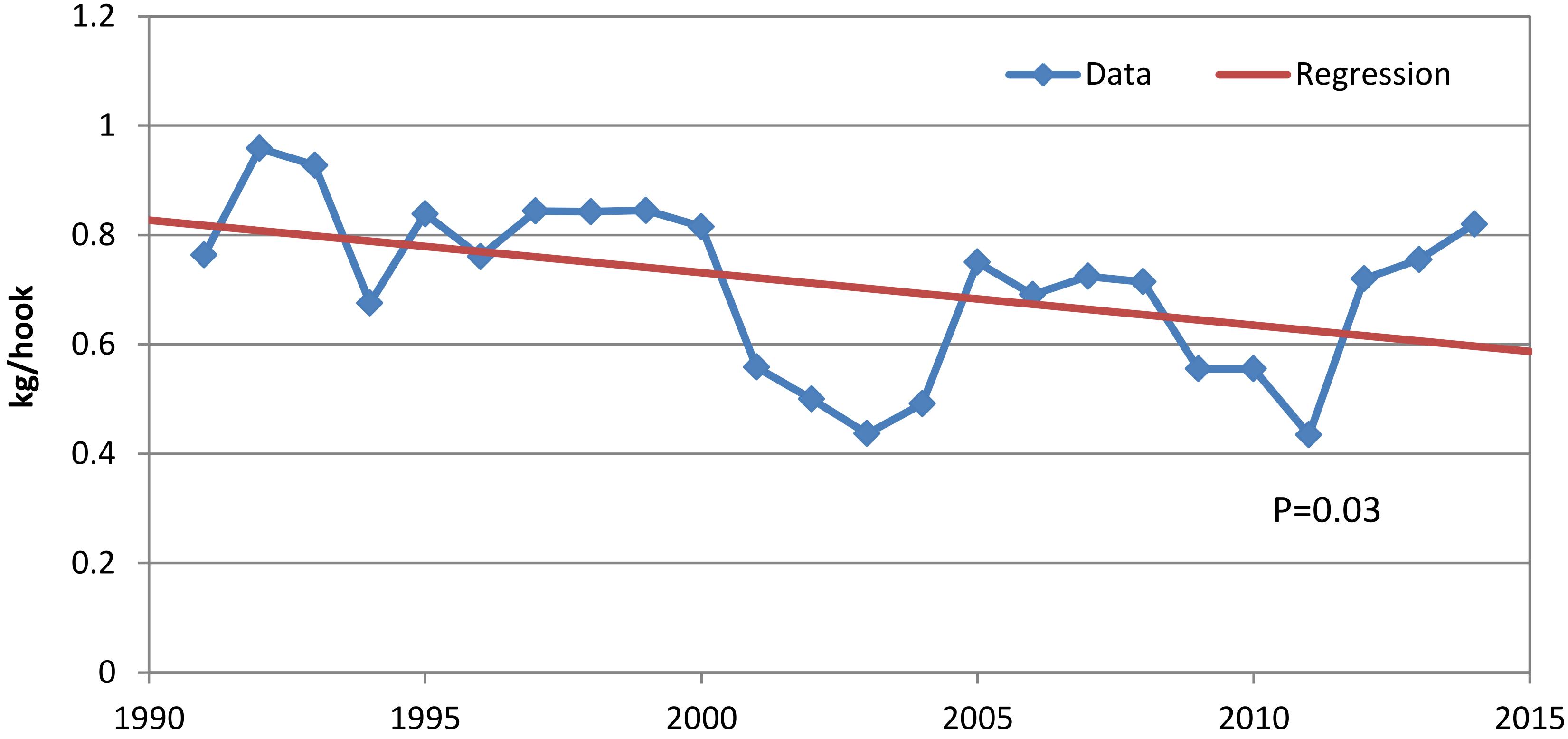
Recent survey size compositions



CPUE (not used in models): trawl fishery



CPUE (not used in models): longline fishery

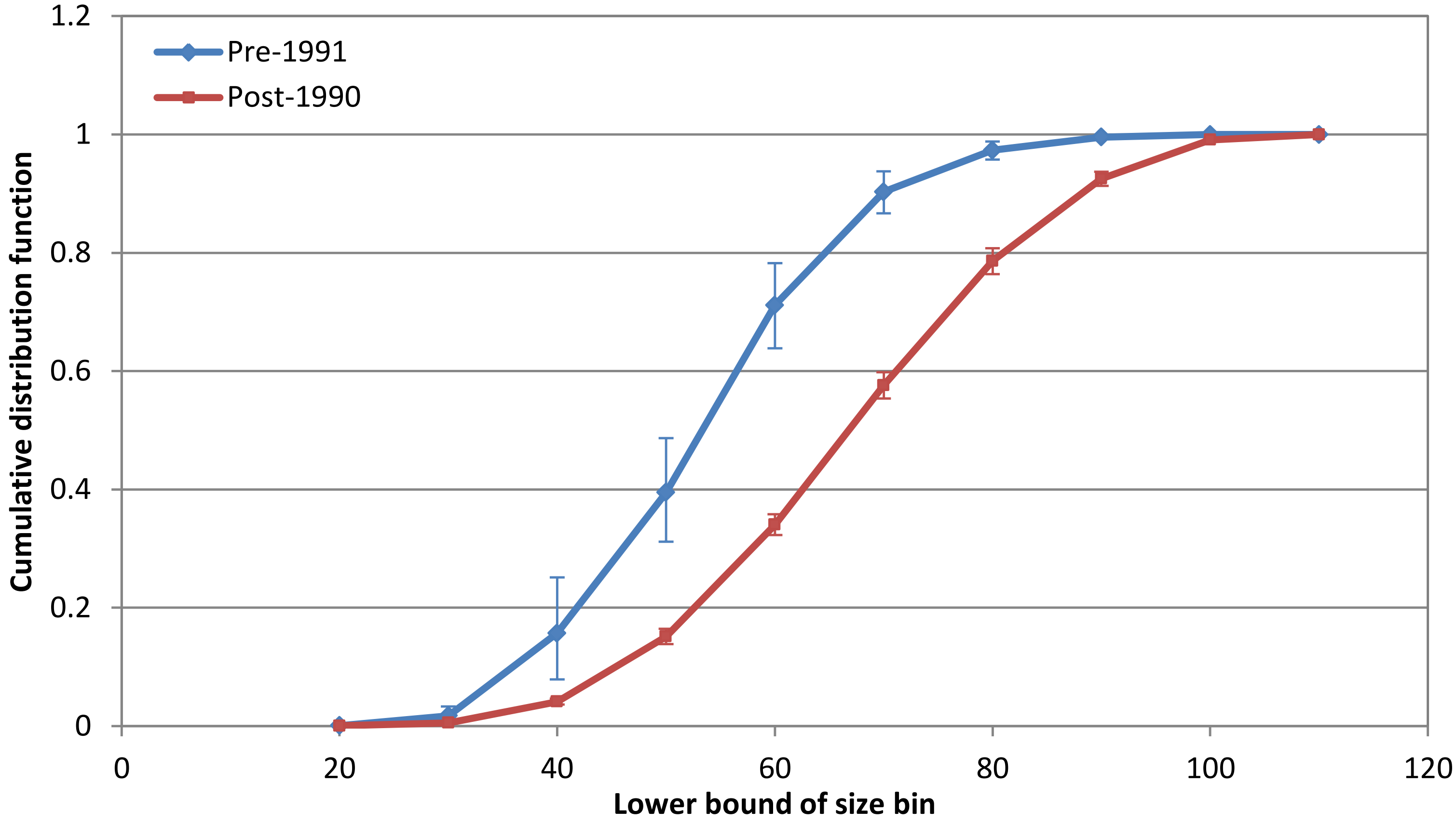


Old news: dropping the pre-1991 *survey* data

- In 2012, SSC asked authors to agree on a standard range of years to use for the AI survey time series
- In 2013, authors proposed to set default as 1991-present, because usage and configurations of the nets in the pre-1991 surveys varied among nations and years, e.g.:
  - In 1980:
    - Data from Japanese vessels were excluded from estimate
    - The two U.S. vessels used two different nets
  - In 1983 and 1986:
    - Data from all vessels were included in estimates
    - Japanese vessels used different nets in those two years
- SSC accepted authors' proposed default

Rationale for omitting *all* pre-1991 data (1 of 3)

- Fishery size compositions are very different between pre-1991 and post-1990 periods (means are compared below)



Rationale for omitting *all* pre-1991 data (2 of 3)

- Some possible hypotheses that could explain the difference:
  1. The samples collected during one or both time periods were not representative
  2. Fishery selectivity at age was dramatically different between the two periods
  3. Recruitment was consistently higher during the earlier period
  4. Fishing mortality was consistently higher during the earlier time period
- The first hypothesis in the above list has not yet been explored
- Tier 3 Model 2 in last year's assessment allowed for all three of the other hypotheses, and last year's Tier 3 Model 1 allowed for the last two
  - The results of those models did not corroborate either the selectivity hypothesis or the recruitment hypothesis
    - Fishery selectivity at age in last year's Model 2 was, on average, about the same between the two time periods
    - Recruitment was, on average, either about the same during the two periods (last year's Model 1) or much higher during the later time period (last year's Model 2)
  - This leaves the fourth hypothesis (see next slide)

Rationale for omitting *all* pre-1991 data (3 of 3)

- Hypothesis #4: Fishing mortality was consistently higher during the earlier time period
- Both of last year's age-structured models did estimate that fishing mortality was consistently much higher during the earlier time period
  - However, this finding was viewed with skepticism by the authors, in part because both models also estimated that biomass was very low during the first part of the time series, which, taken together with the estimates of very high fishing mortality during that period, implies that fishermen were expending very large amounts of effort in pursuit of very few fish, which did not seem to fit with the history of the fishery's development
  - Moreover, the survey biomass index has declined fairly consistently during the post-1990 period (see next subsection), which the models could not reconcile with a decreasing fishing mortality trend and a level or increasing recruitment trend
- Given the inability of last year's models to reconcile the pre-1991 fishery size composition data with the post-1990 data, the models presented this assessment omitted the pre-1991 fishery size composition data
- Given the resulting lack of any ability to estimate fishery selectivity for the pre-1991 period, the pre-1991 catch data were eliminated as well
- Note also that both the Team and SSC recommended omitting all pre-1991 data

Model structure

Model 1 (Tier 5)

- Random effects model recommended by the Survey Averaging Working Group
  - Same model used last year
- Main features:
  - Simple, state-space model of the “random walk” variety
  - Process error and observation error both assumed to be lognormally distributed
  - Only parameter is the log of the log-scale process error standard deviation
  - Observation error CVs are equal to the sampling error CVs estimated from the haul-by-haul survey data

Common features of the Tier 3 models (1 of 2)

- This is the sixth review of age-structured models for AI Pcod
  - Preliminary and final 2012 assessments
  - Preliminary and final 2013 assessments
  - Preliminary and final 2014 assessments
- Initial approach was to mimic EBS model, but simpler
  - Approach has evolved since then
- Ways in which Models 2 and 3 differ from *both* EBS M1 and M2:
  - Data time series starts in 1991 instead of 1977
  - Data length bins extended out to 150 cm instead of 120 cm
  - σ_R estimated internally
    - Fixed in EBS Model 1, tuned iteratively in EBS Model 2
  - Q estimated with informative prior distribution
    - Fixed in EBS Model 1, estimated freely in EBS Model 2

Common features of the Tier 3 models (2 of 2)

- Other ways in which Models 2 and 3 differ from EBS Model 2:
  - Q constant, rather than time-varying
- Other ways in which Models 2 and 3 differ from EBS Model 1:
  - Survey samples age 1 fish at true age 1.5 instead of 1.41667
  - Selectivity (fishery and survey) follows random walk with age
    - Parameters consist of the backward first differences of selectivity on the log scale, rather than selectivity itself
  - Following quantities are tuned iteratively:
    - Potentially, each selectivity parameter can be time-varying with annual additive devs, where the sigma term is tuned to match the standard deviation of the estimated devs
    - Mean of normal prior for each selectivity parameter is tuned so that the set of prior means is consistent with logistic selectivity
    - Constant standard deviation of normal prior for all selectivity parameters is tuned so that the CV (on the selectivity scale, not the parameter scale) is at least 50% for all ages

Distinguishing feature of the Tier 3 models

- Model 2 is the same as Model 1 from the preliminary assessment
- For Model 3, Team requested "*a variant … with the priors tightened enough that the survey selectivity schedule is smoother and more like a logistic curve*"
- Left to authors to determine *how much* "more like"
- Authors' decision: tighten the priors just enough to split the difference between the curve estimated by Model 2 and a logistic curve
- Results:
  - Model 2 prior standard deviation = 0.319
    - Implies a minimum (across age) CV of 50% (selectivity scale)
  - Model 3 prior standard deviation = 0.078
    - Implies a minimum (across age) CV of 13.3% (selectivity scale)

Results

Objective function and parameter counts

- Objective function components (Tier 3 models):

Objective function component	Model 2	Model 3
Equilibrium catch	0.001	0.002
Survey abundance	-11.619	-9.270
Fishery size composition	102.218	101.117
Survey size composition	211.073	208.984
Age composition	11.519	15.943
Recruitment	-4.511	-0.174
Priors	17.680	20.262
"Softbounds"	0.001	0.001
Parameter *dev* s	12.039	20.438
Total	338.400	357.302

- Parameter counts (Tier 3 models):

Parameter counts	Model 2	Model 3
Unconstrained parameters	10	10
Parameters with priors	41	41
Constrained deviations	152	152
Total	203	203

Fit to survey index: statistics

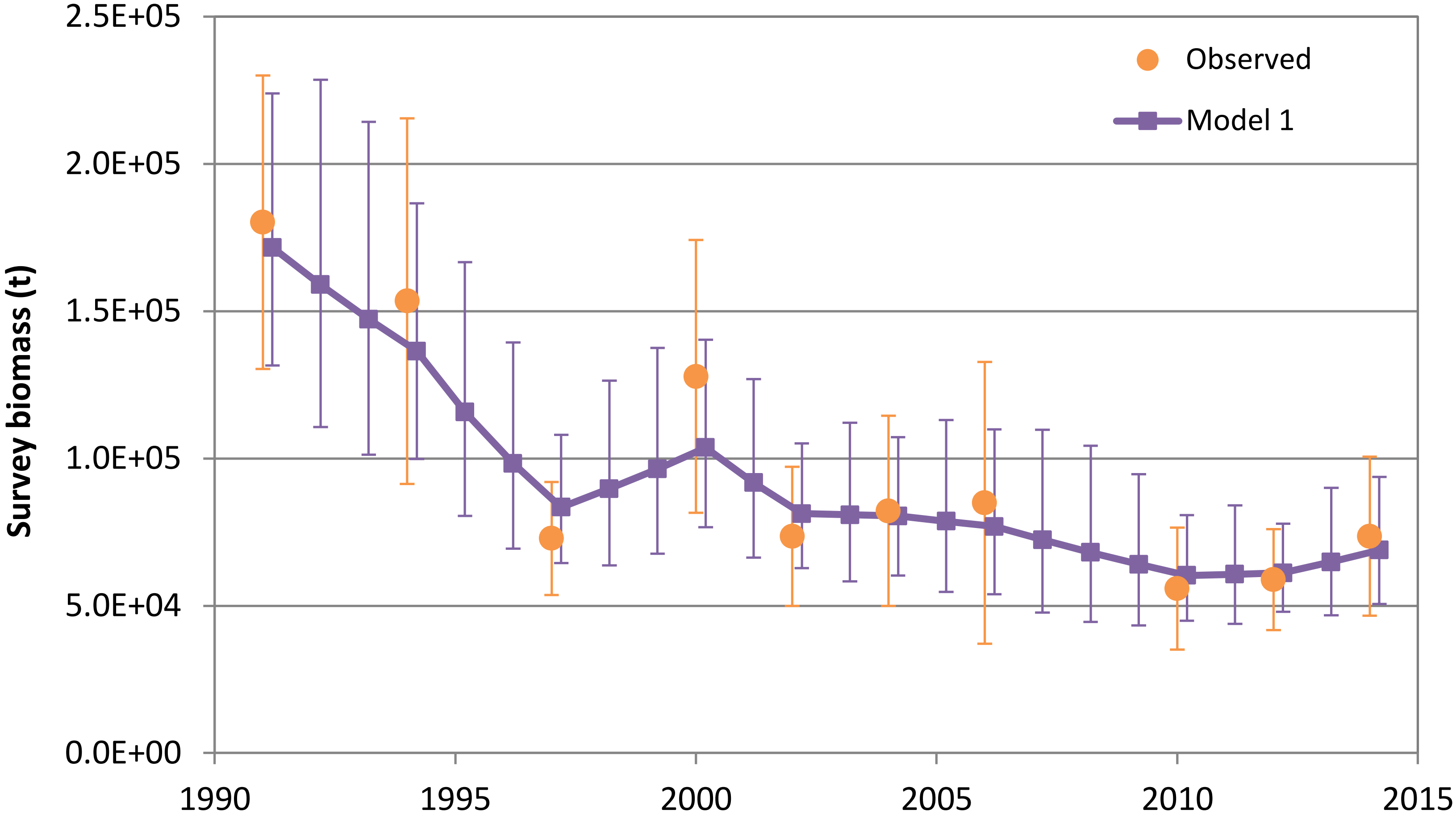
- Model 1 (index = biomass)

Statistic	Value
Correlation (observed:expected)	0.98
Root mean squared error	0.11
Mean normalized residual	0.06
Standard deviation of normalized residuals	0.63

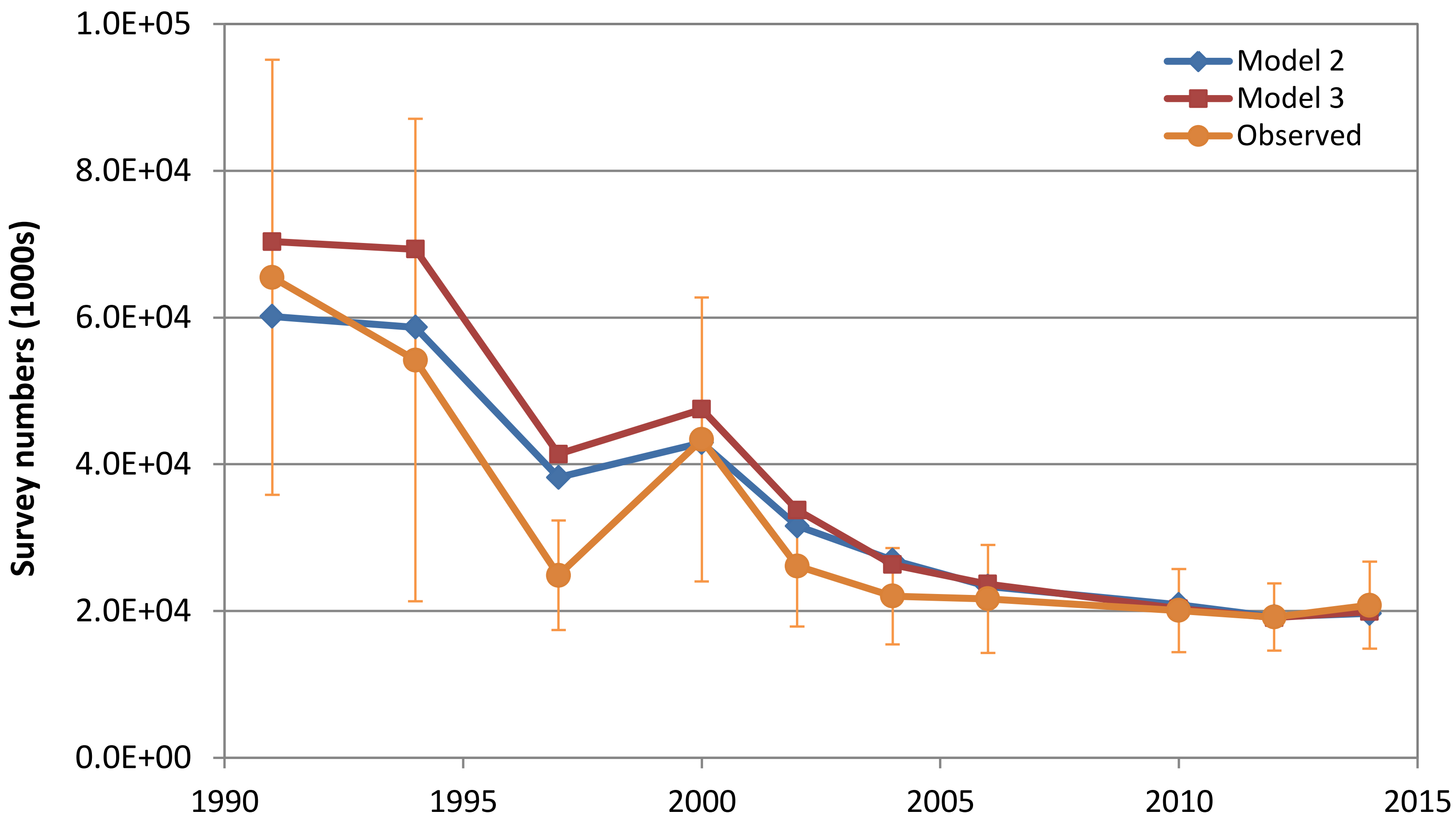
- Models 2 and 3 (index = abundance; mean SE=0.18)

Statistic	Model 2	Model 3
Correlation (observed:expected)	0.95	0.96
Root mean squared error	0.17	0.21
Mean normalized residual	-0.56	-0.79
Standard deviation of normalized residuals	0.98	1.07

Fit to survey biomass (Model 1)



Fit to survey abundance (Models 2 and 3)



Fit to composition data: statistics

- Size composition data:

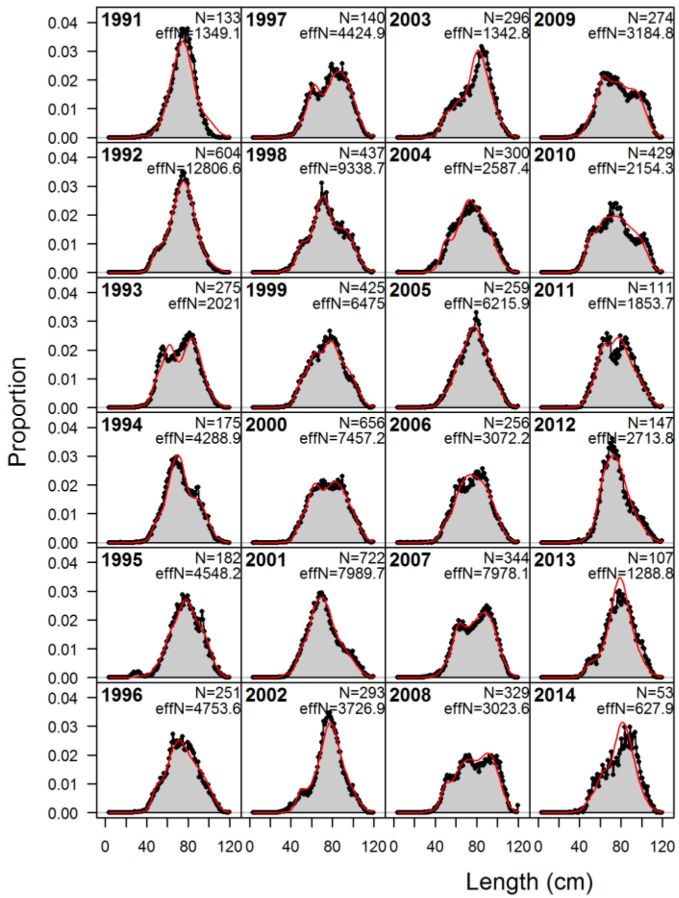
			Mean(Neff)/mean(Ninp)		Harm(Neff)/mean(Ninp)	
Fleet	Nrec	Mean(Ninp)	Model 2	Model 3	Model 2	Model 3
Fishery	24	300	14.62	15.19	8.77	8.01
Survey	10	300	3.50	3.55	2.29	2.31

- Age composition data:

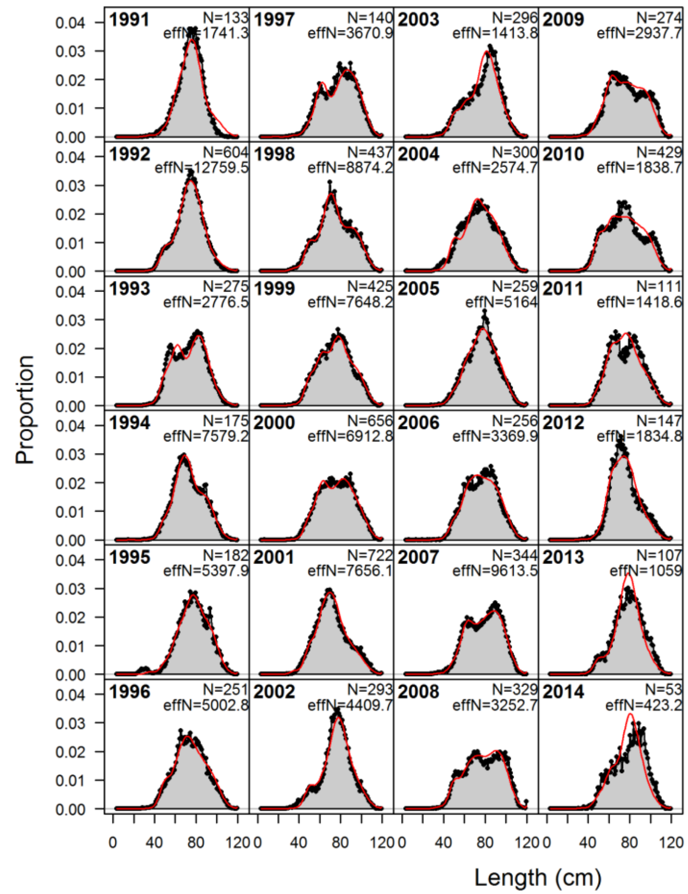
			Mean(Neff)/mean(Ninp)		Harm(Neff)/mean(Ninp)	
Fleet	Nrec	Mean(Ninp)	Model 2	Model 3	Model 2	Model 3
Survey	2	300	1.05	0.69	0.79	0.52

Fit to fishery sizecomps: pictures

- Model 2

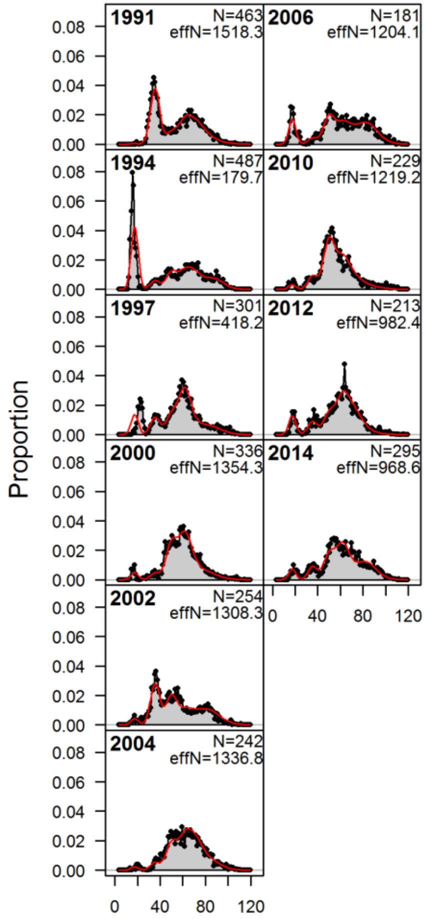


Model 3

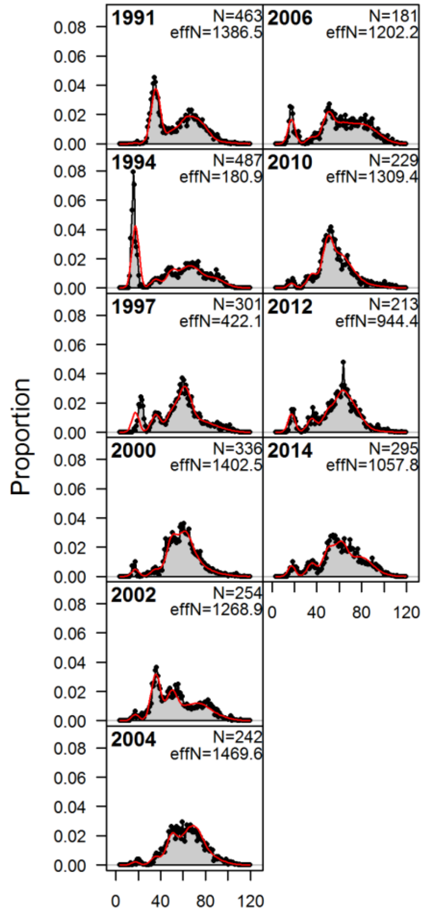


Fit to survey sizecomps: pictures

- Model 2

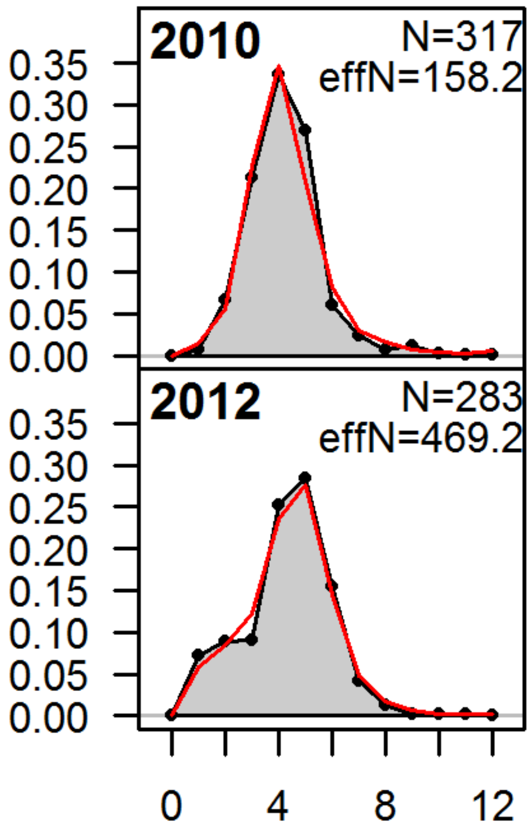


Model 3

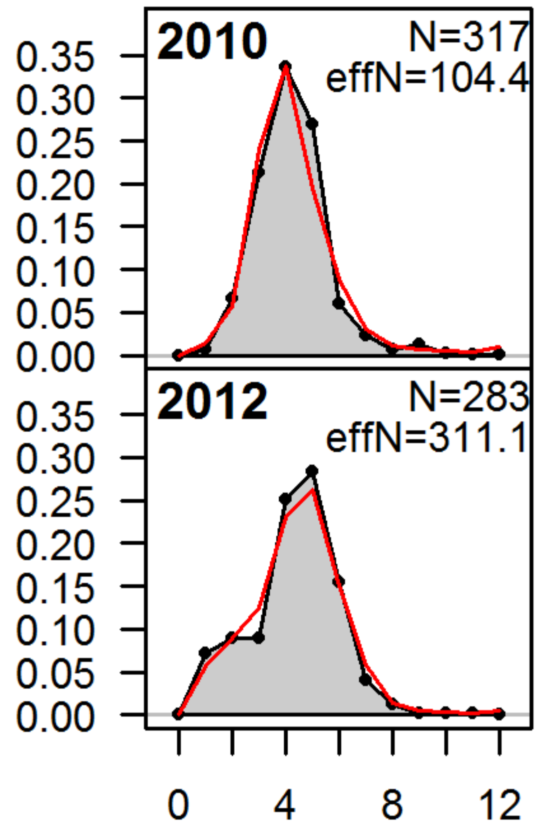


Fit to survey agecomps: pictures

- Model 2

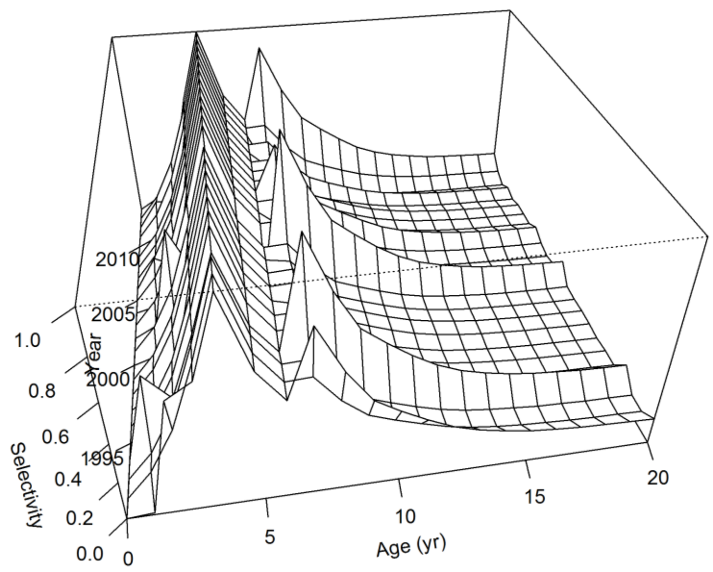


Model 3

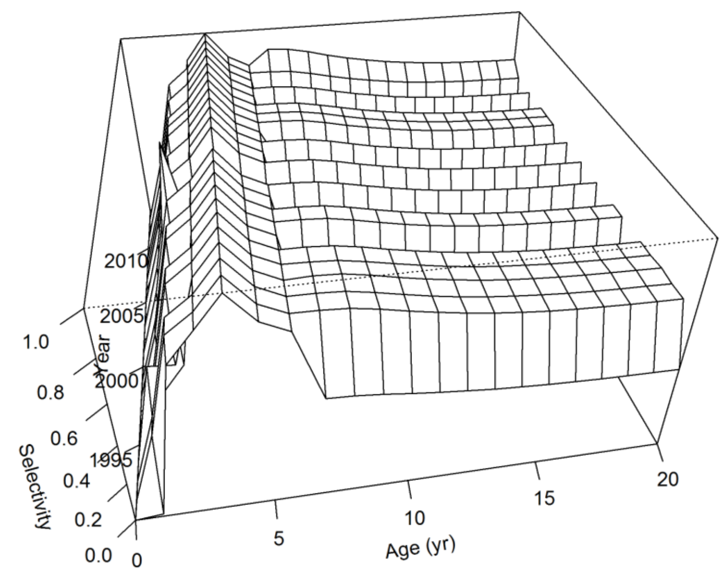


Survey selectivity

- Model 2

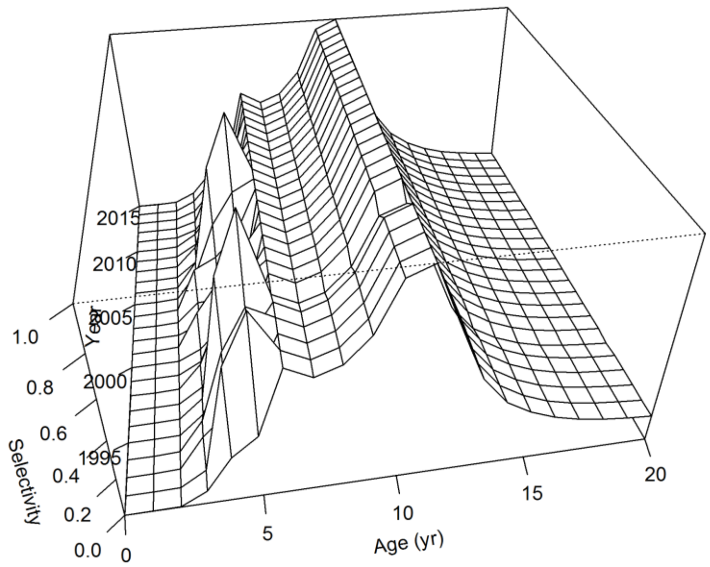


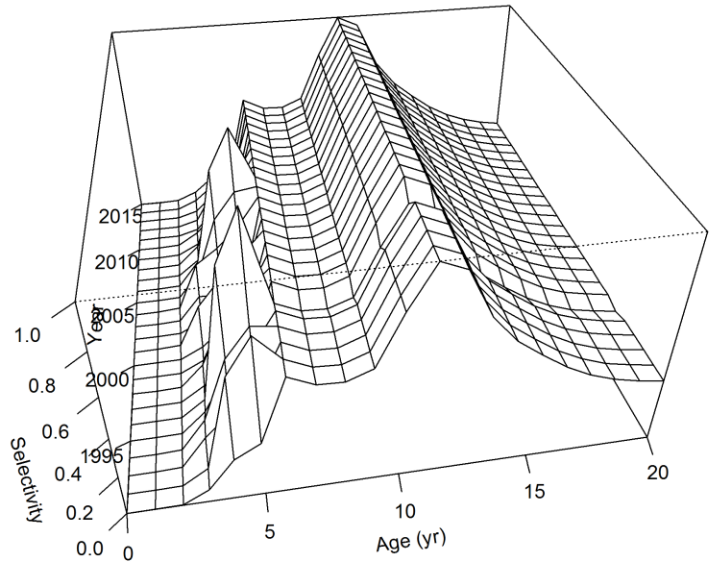
Model 3



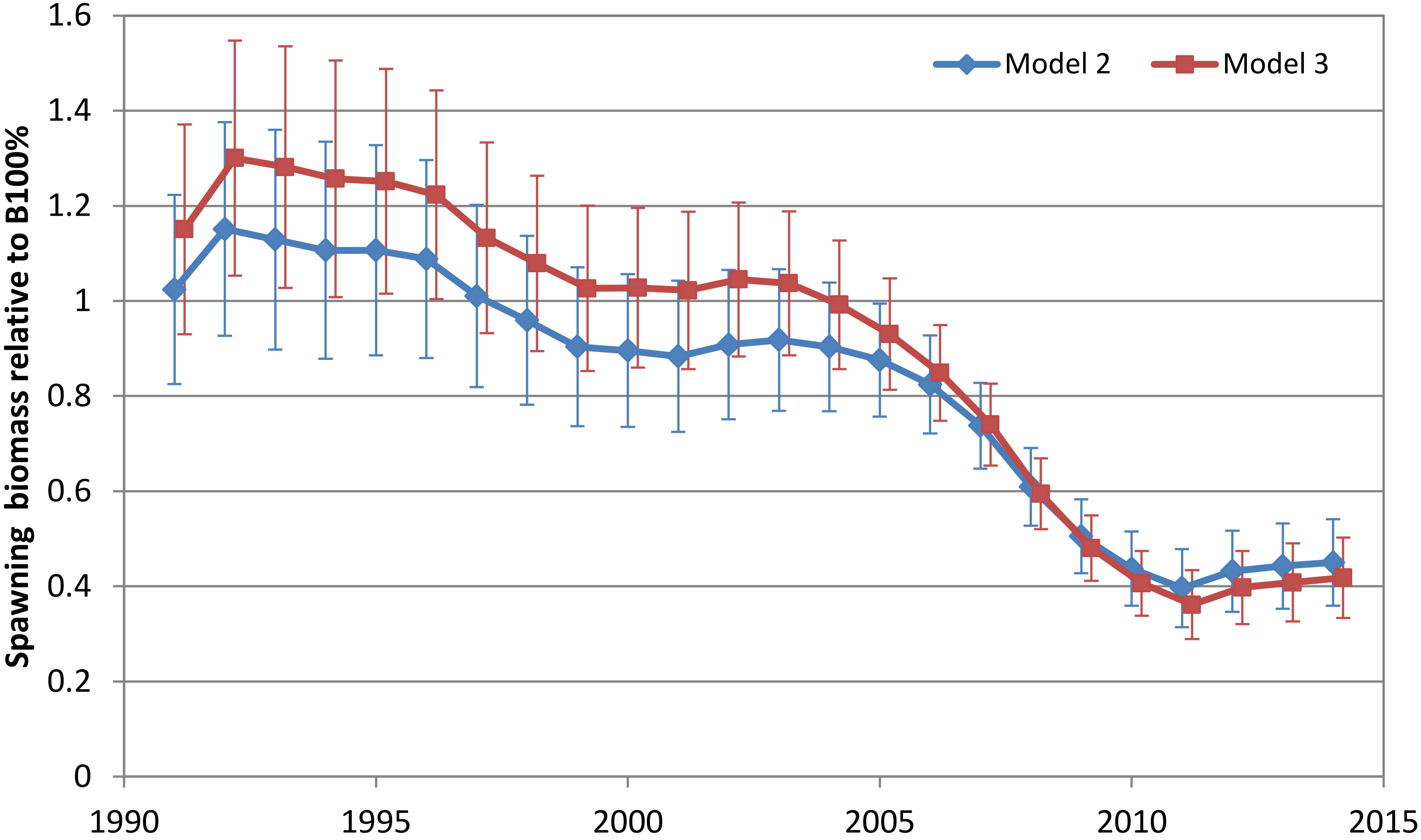
Fishery selectivity

- Model 2 Model 3

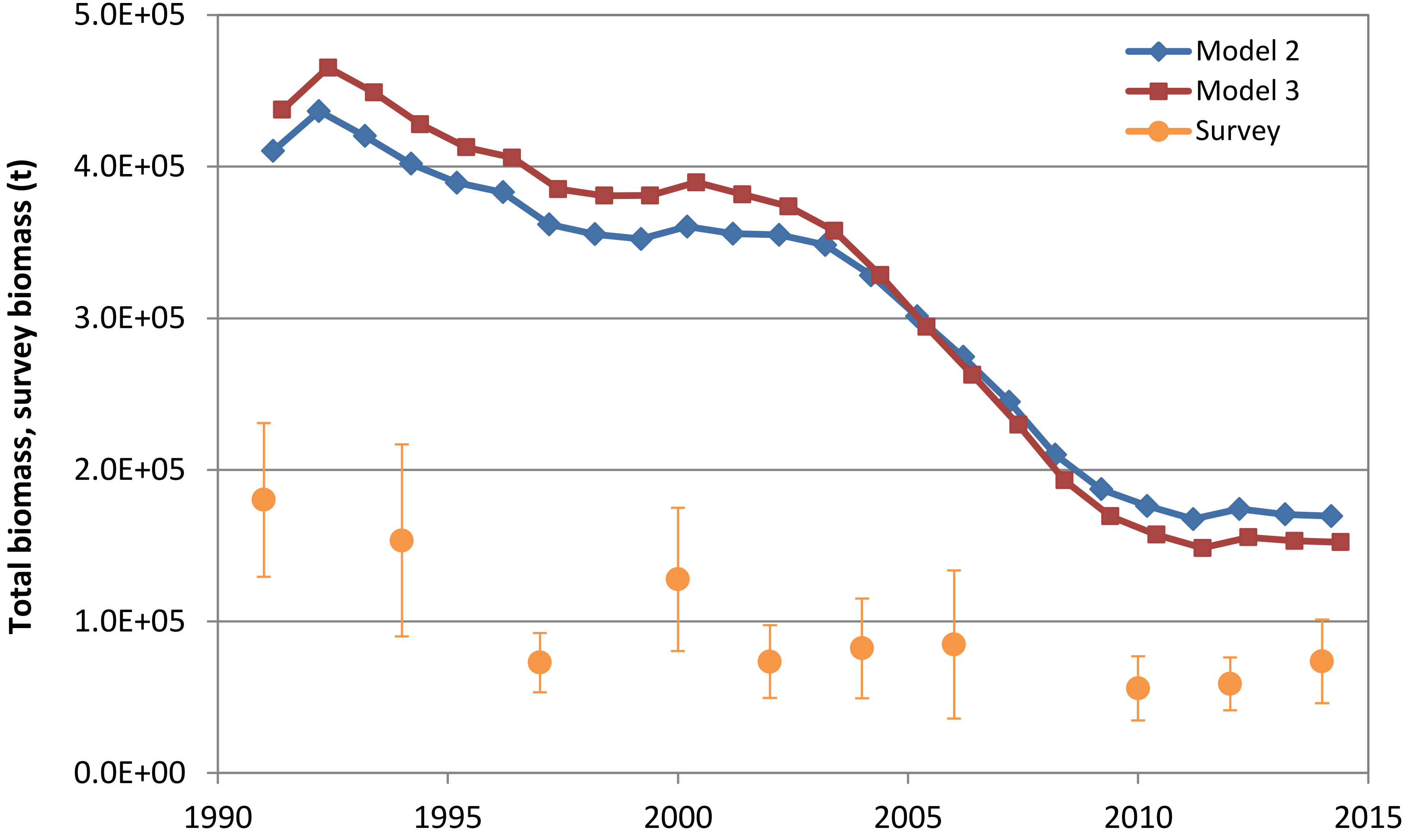




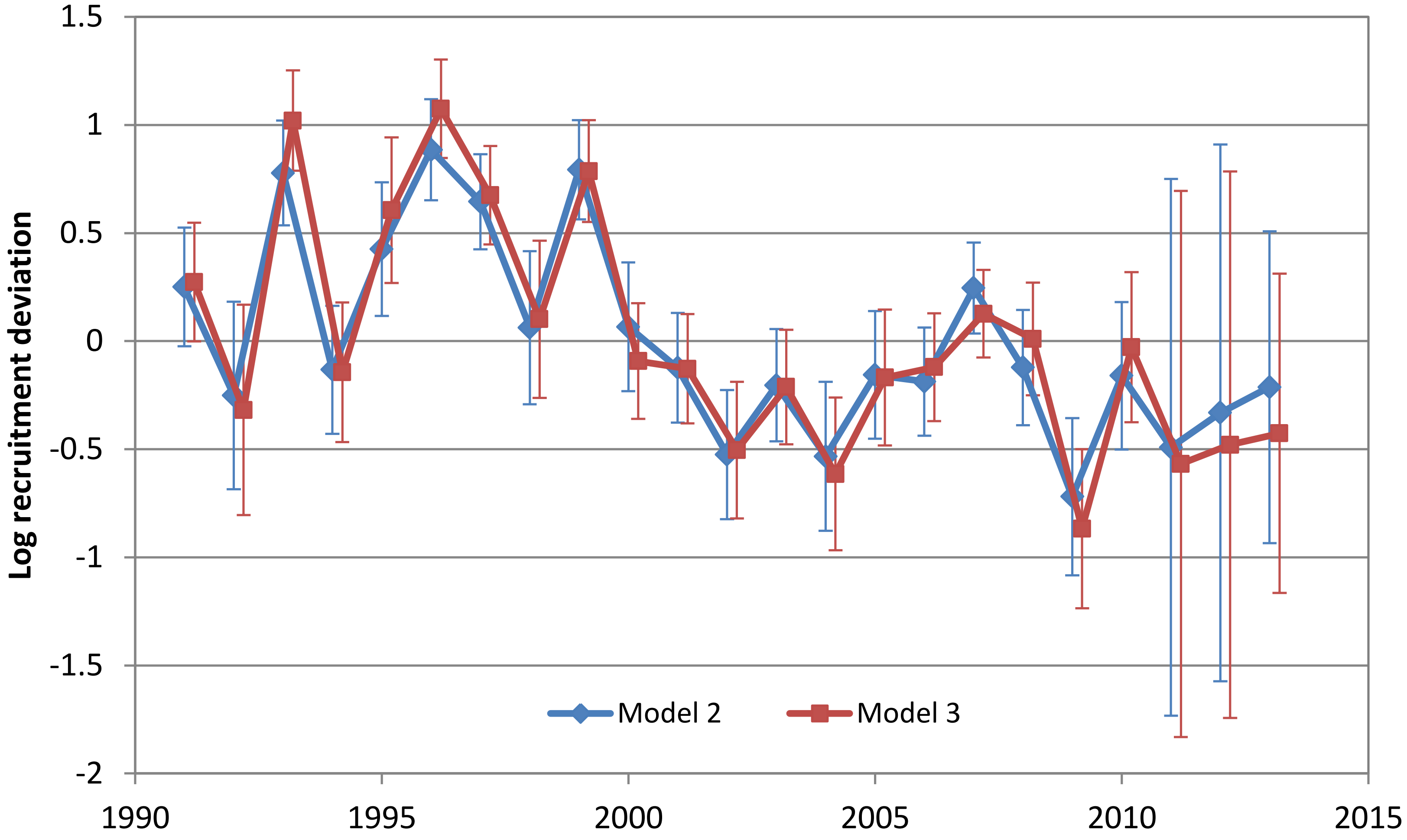
Spawning biomass relative to $B_{100\%}$



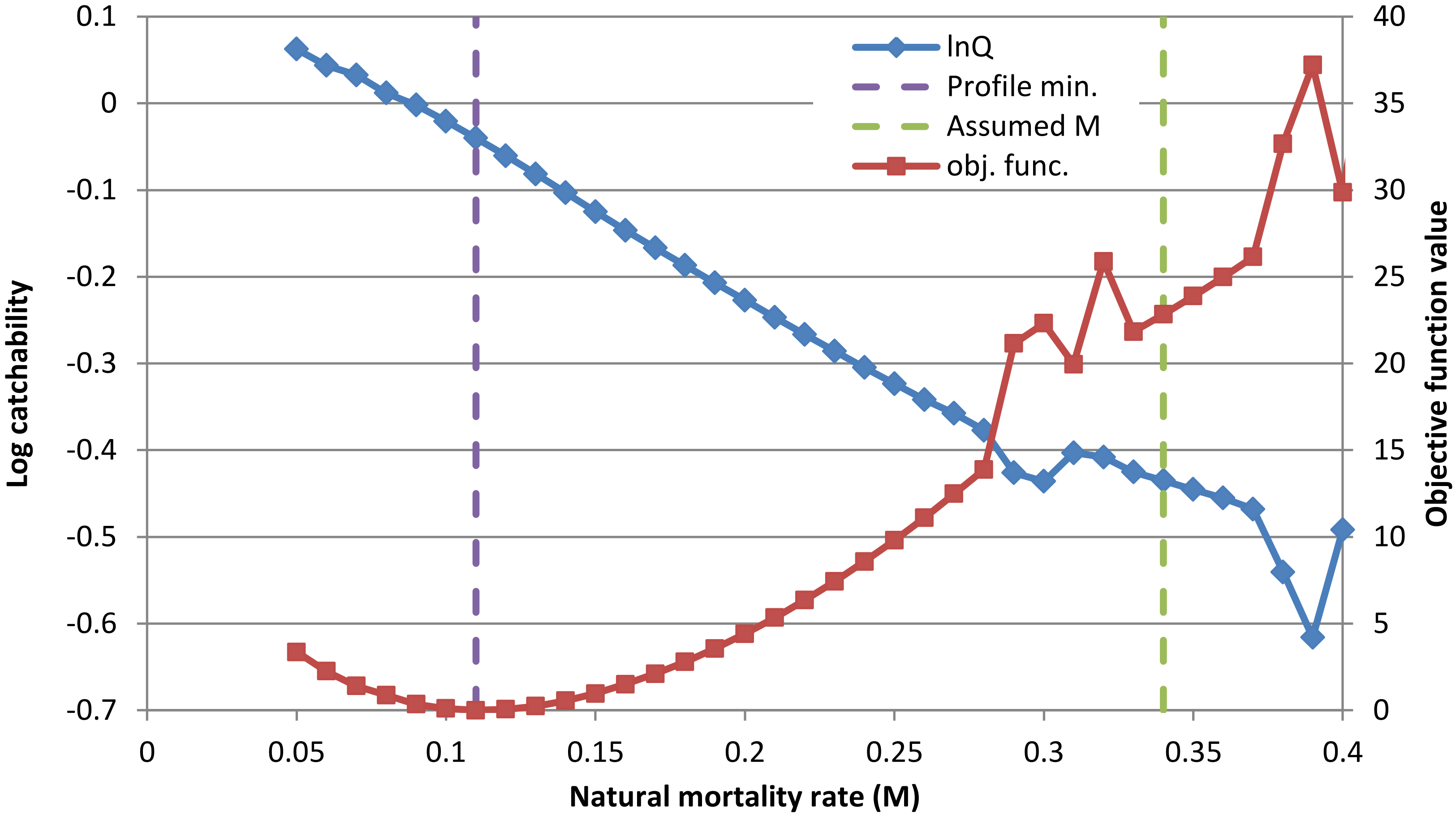
Age 0+ biomass time series (with survey)



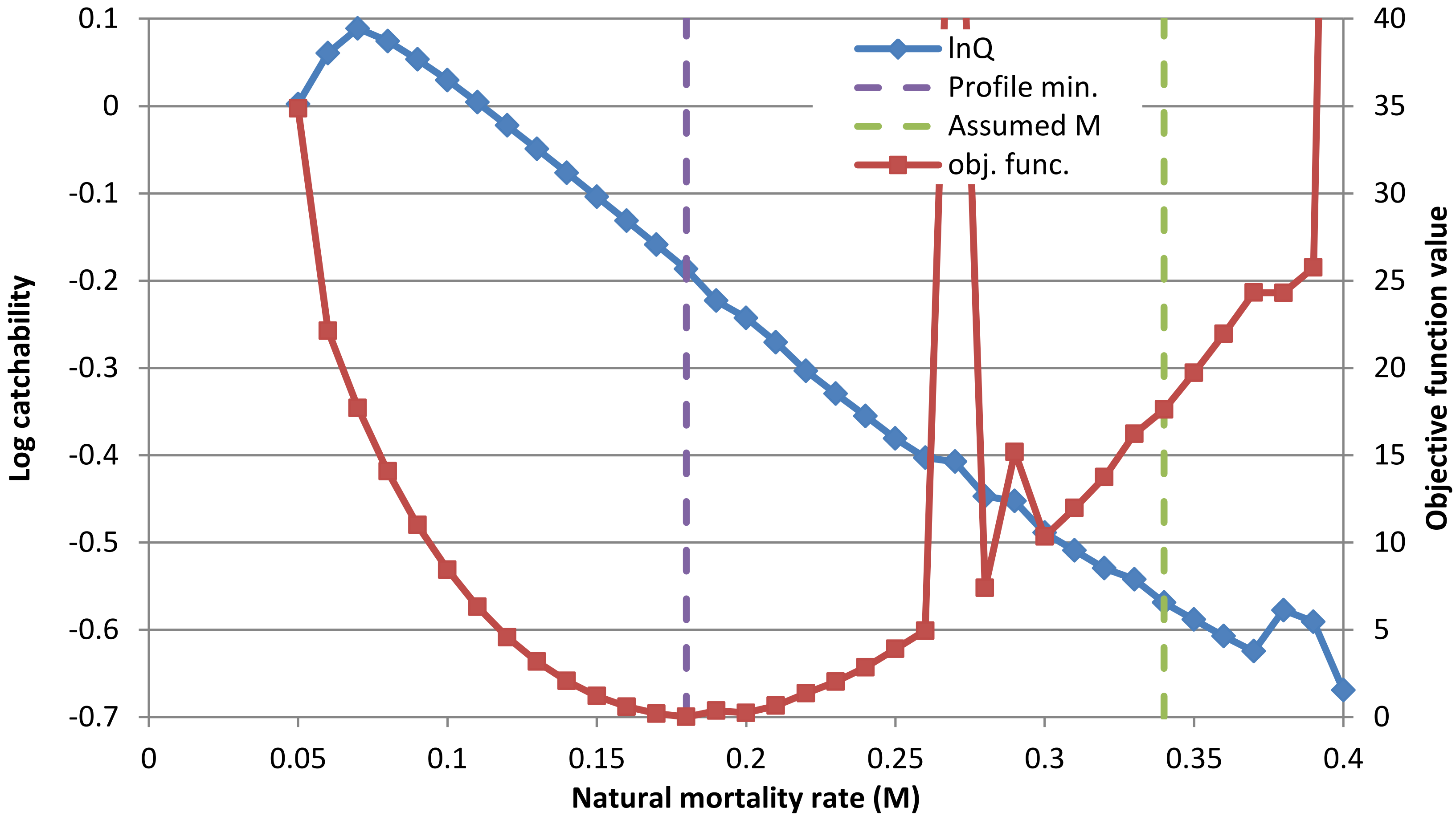
Age 0 recruitment deviations



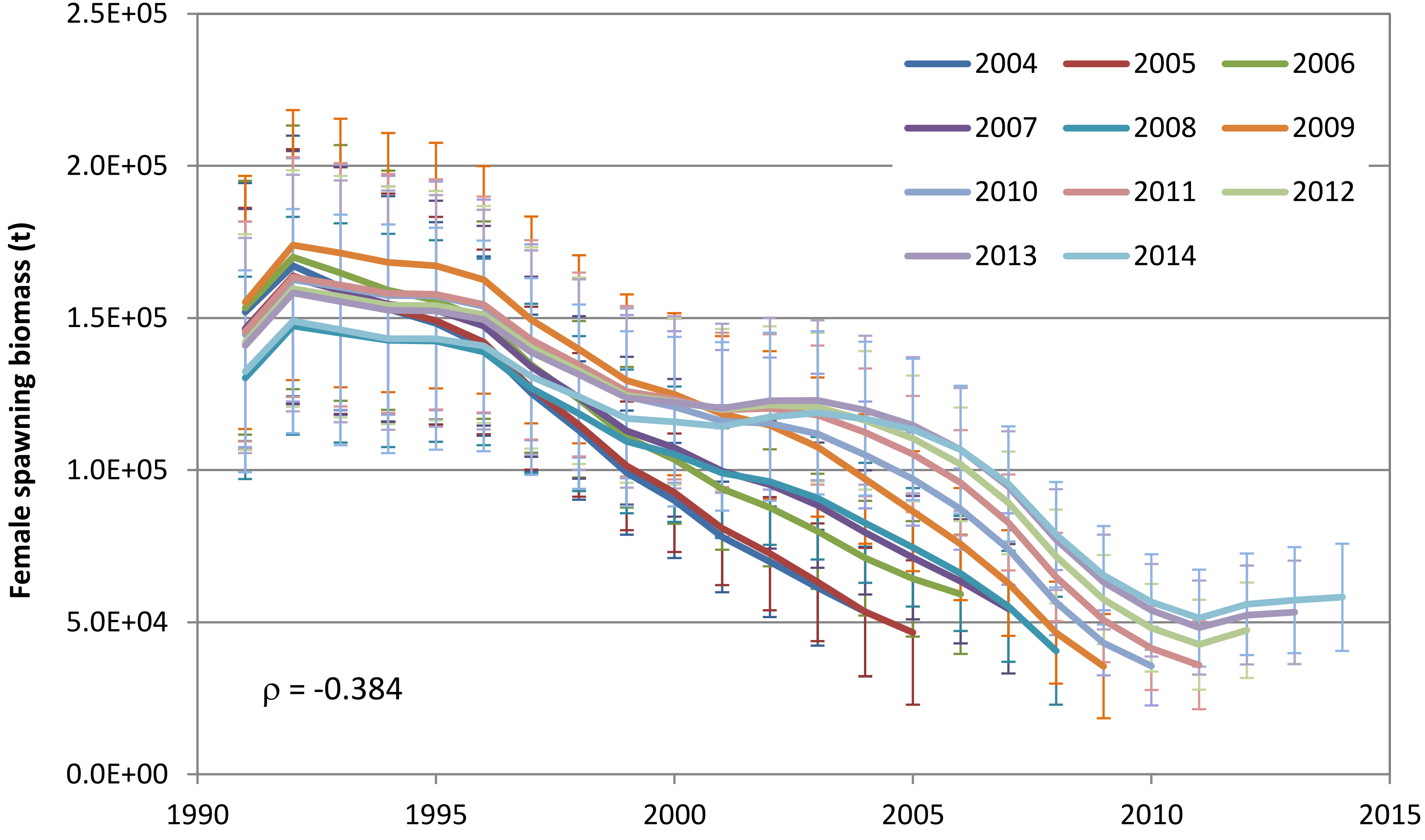
Likelihood profile w.r.t. *M* (Model 2)



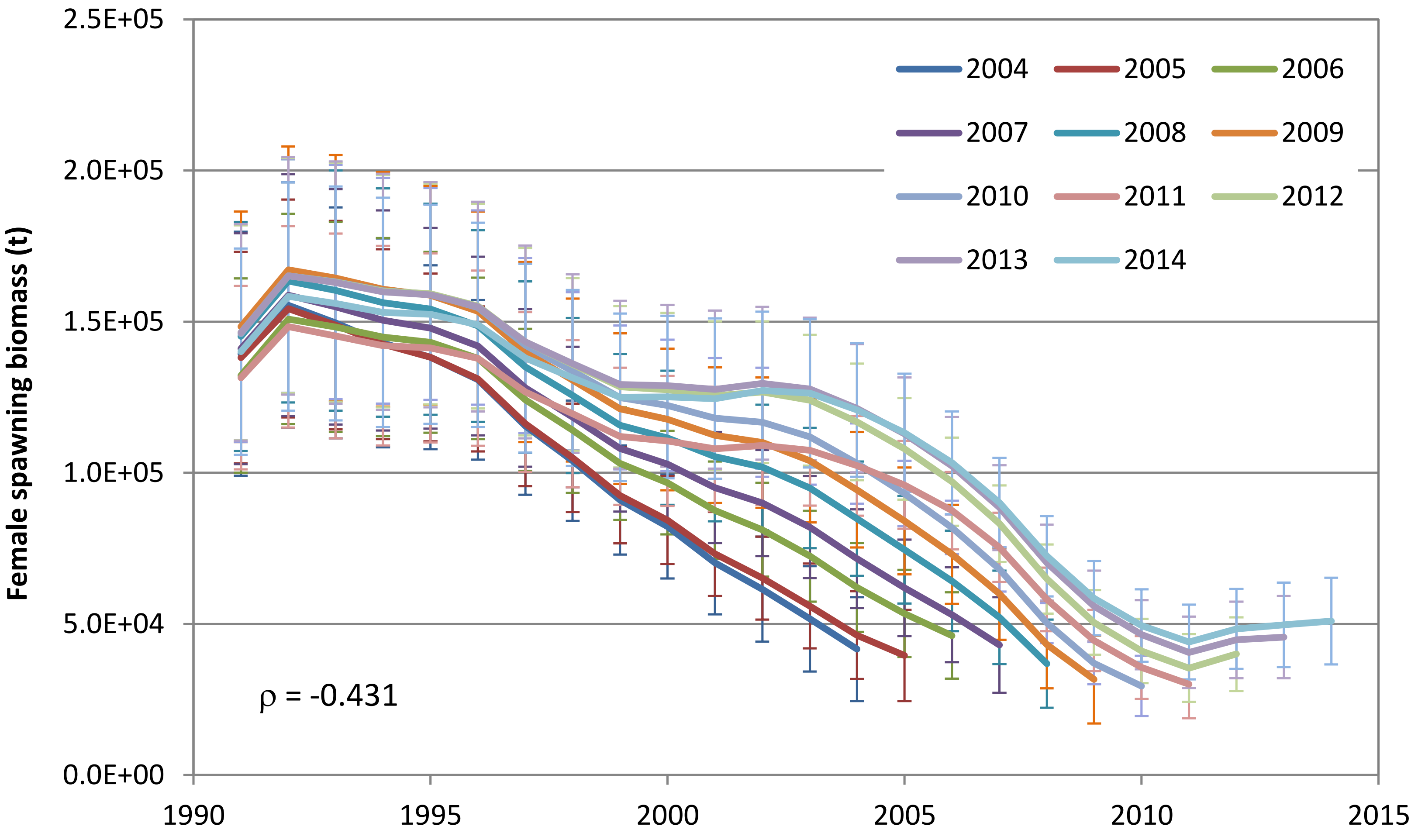
Likelihood profile w.r.t. M (Model 3)



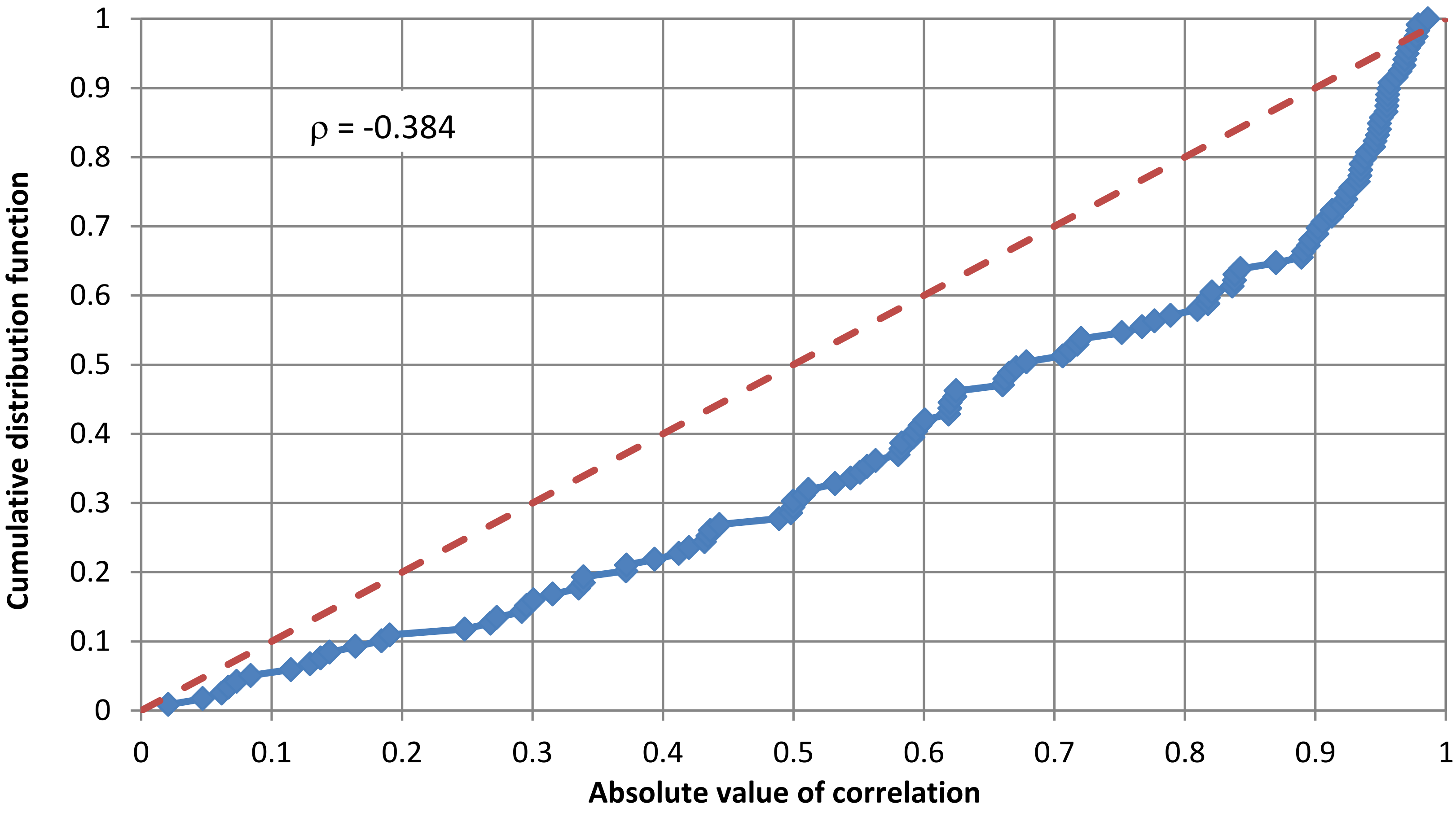
Spawning biomass retrospective (Model 2)



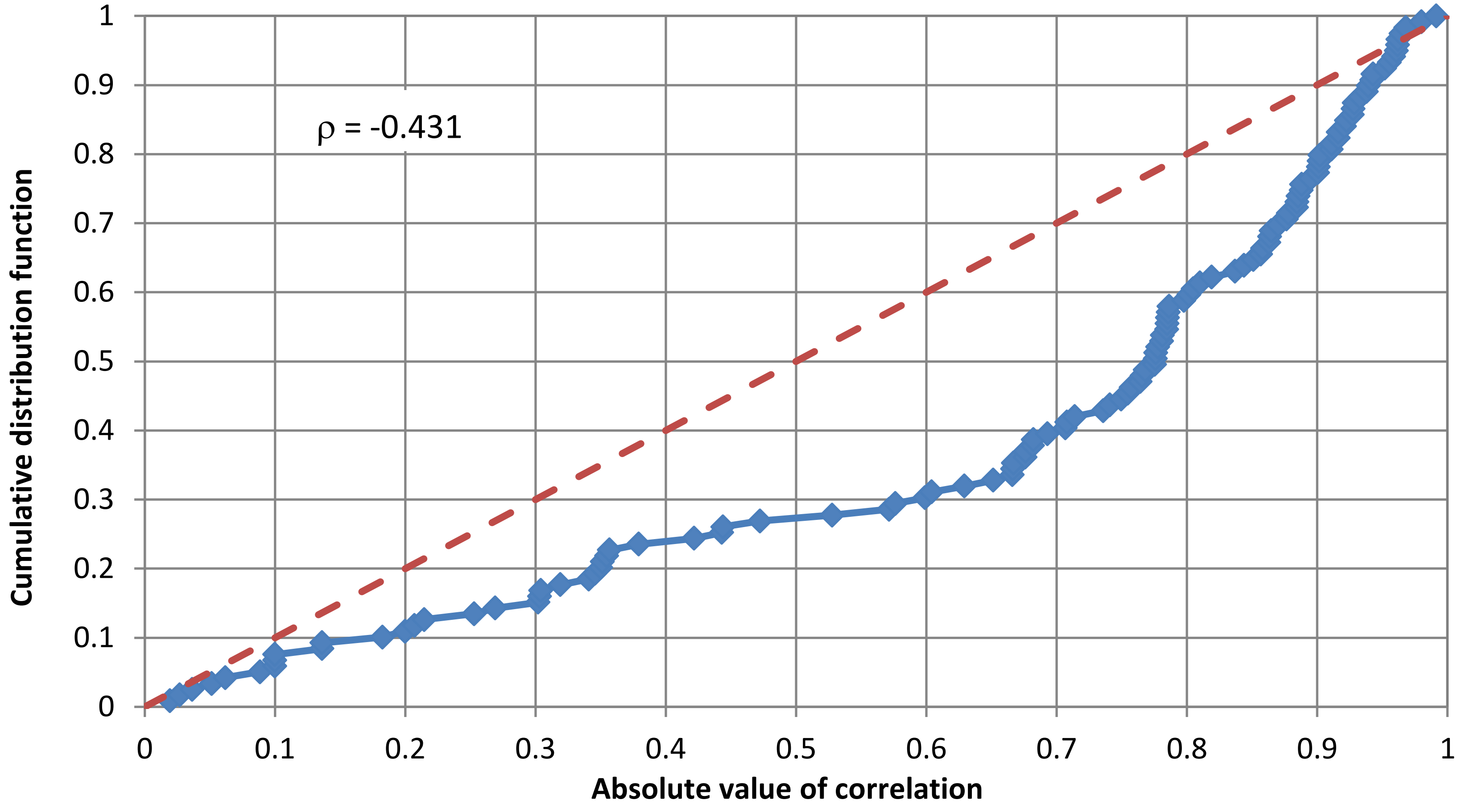
Spawning biomass retrospective (Model 3)



Parameter:peel correlations (Model 2)



Parameter:peel correlations (Model 3)



Final model and projections

Model evaluation criteria

- These are the criteria used by the authors:
  1. Does the model contain new features that merit further evaluation before being adopted?
  2. Would use of the model for setting 2015-2016 harvest specifications pose a significant risk to the stock?

Evaluation with respect to criterion #1

- One new feature of Models 2 and 3 that stands out is use of random walk selectivity
  - See EBS presentation for further details
- A second new feature that may merit further investigation is the absence of the pre-1991 fishery data in Models 2 and 3
  - While removing these data resulted in much better fits to the remaining data, there is some possibility that the resulting estimates of $B_{40\%}$ may be biased
  - This would be the case if mean recruitment in the pre-1991 portion of the time series were substantially different from that in the post-1990 period
  - As noted previously, it might be possible to reconcile the difference in size compositions between the two parts of the time series with the other data in the model if fishery selectivity were sufficiently different between the two periods
  - Unfortunately, although one of last year's models allowed for time-varying selectivity, it failed to find substantial differences between the two periods
  - However, the method used for determining the appropriate amount of time variability can tend to underestimate this amount under certain conditions
  - An alternative for future exploration might be to specify period-specific fisheries, and then allow for an appropriate amount of time-variability within each period
  - If this is successful, then perhaps the pre-1991 fishery data could be restored

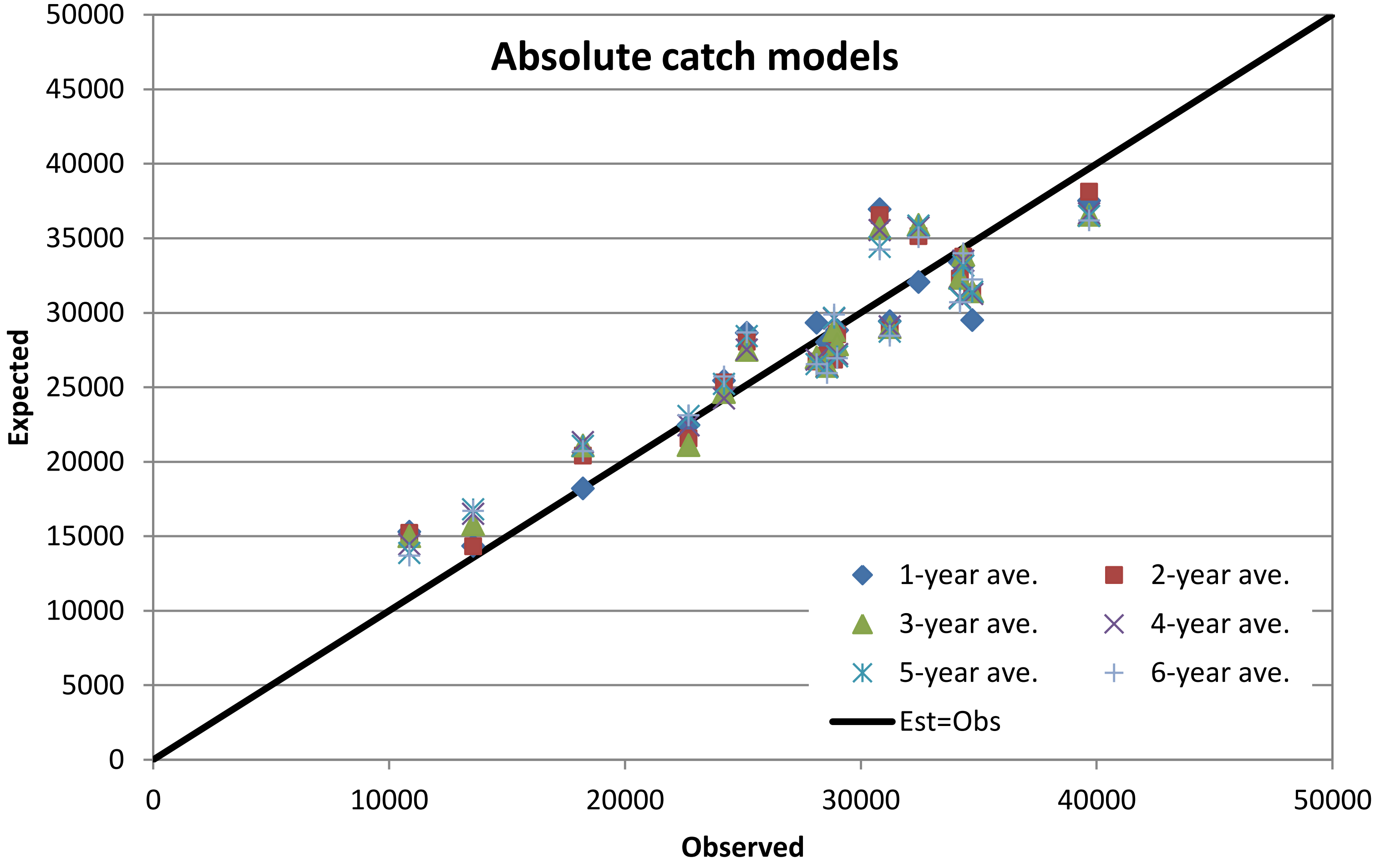
Evaluation with respect to criterion #2

- A formal risk analysis has not been undertaken in this assessment, but one feature of Models 2 and 3 that merits attention in this context is the difference between these models' estimates of total biomass and the biomass estimated by the survey
- The ratio of model biomass to survey biomass has an average (across years) value of about 3.3 for both models
- While it is not inconceivable that the survey misses so many fish, it does not seem wise to accept such an enormous discrepancy without first examining other hypotheses more fully
- Overall conclusion: adopt Model 1 for this year
- However, full results for all three models are shown in the assessment

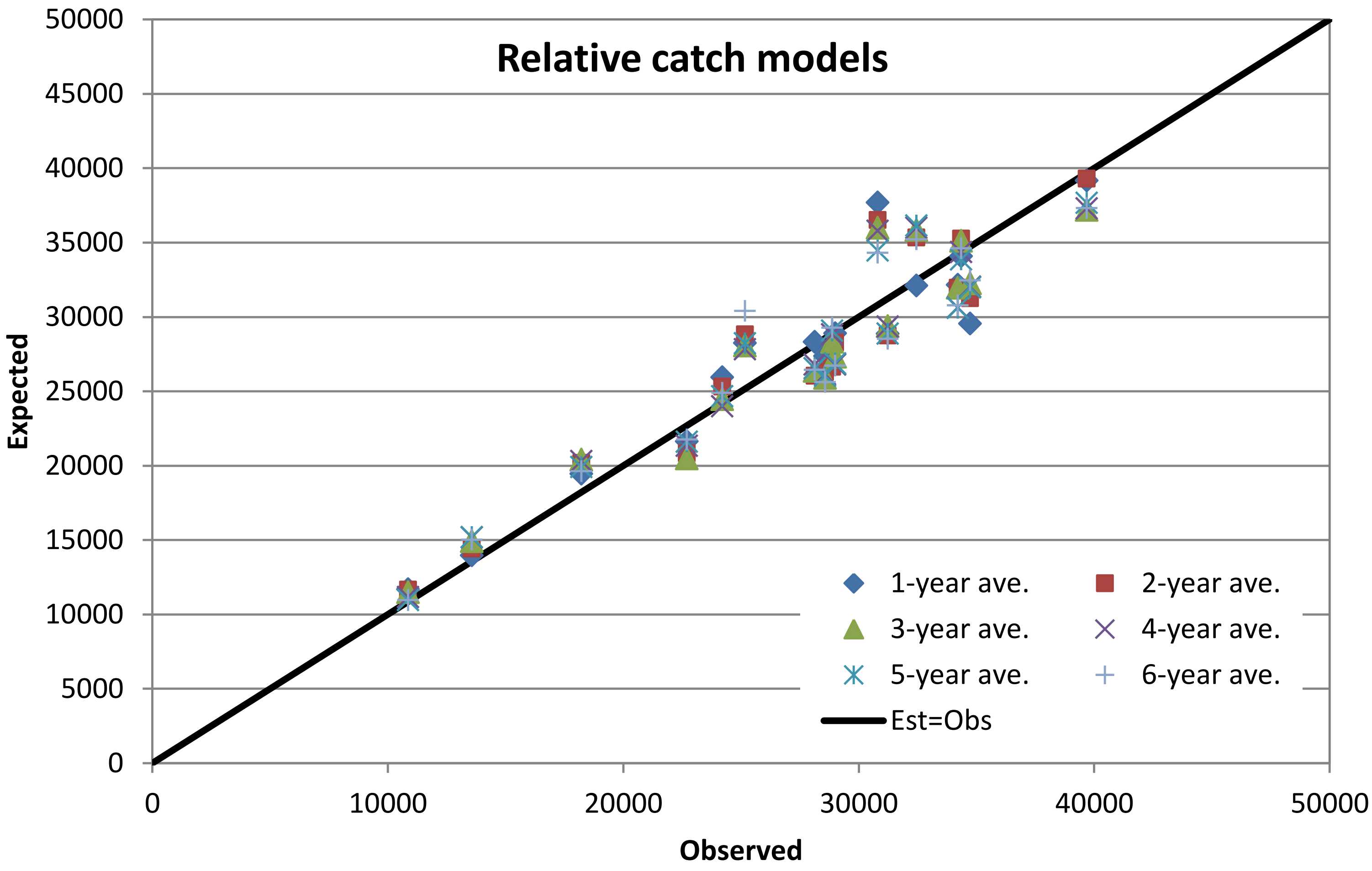
Current-year catch estimation (1 of 3)

- Twelve estimators (2 groups of 6) examined overall
  - Each group examined running averages of 1-6 years
- First group used “absolute” catch
  - Year-end catch for current year = catch through August + average Sep-Dec *catch* from last *N* yrs
- Second group used “relative” catch
  - Year-end catch for current year = catch through August / average Jan-Aug *proportion* from last *N* yrs
- Results:
  - All group 2 estimators did better than all group 1 estimators
  - Best group 2 estimator used *N*=5 (log-scale RMSE = 0.08)

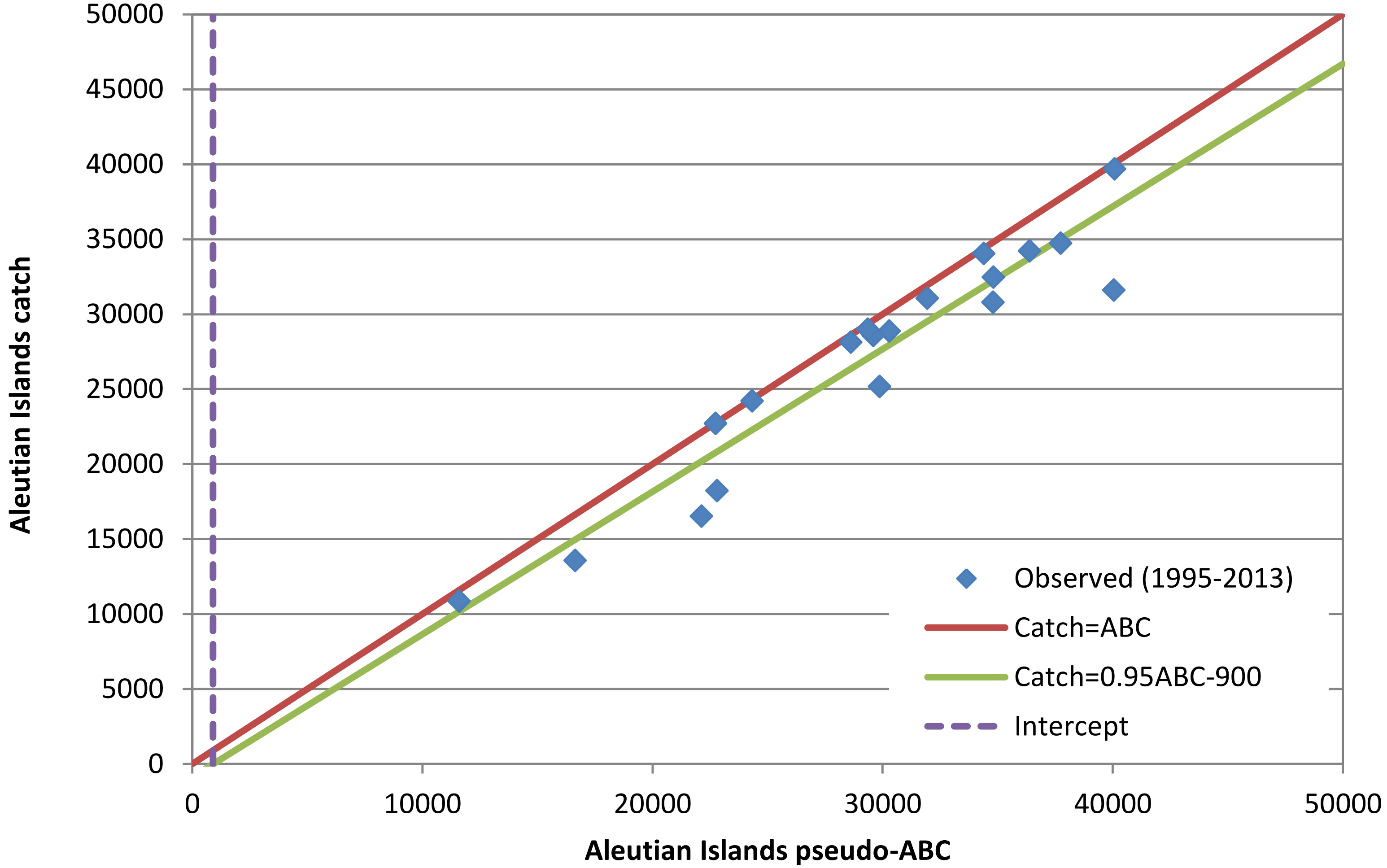
Current-year catch estimation (2 of 3)



Current-year catch estimation (3 of 3)



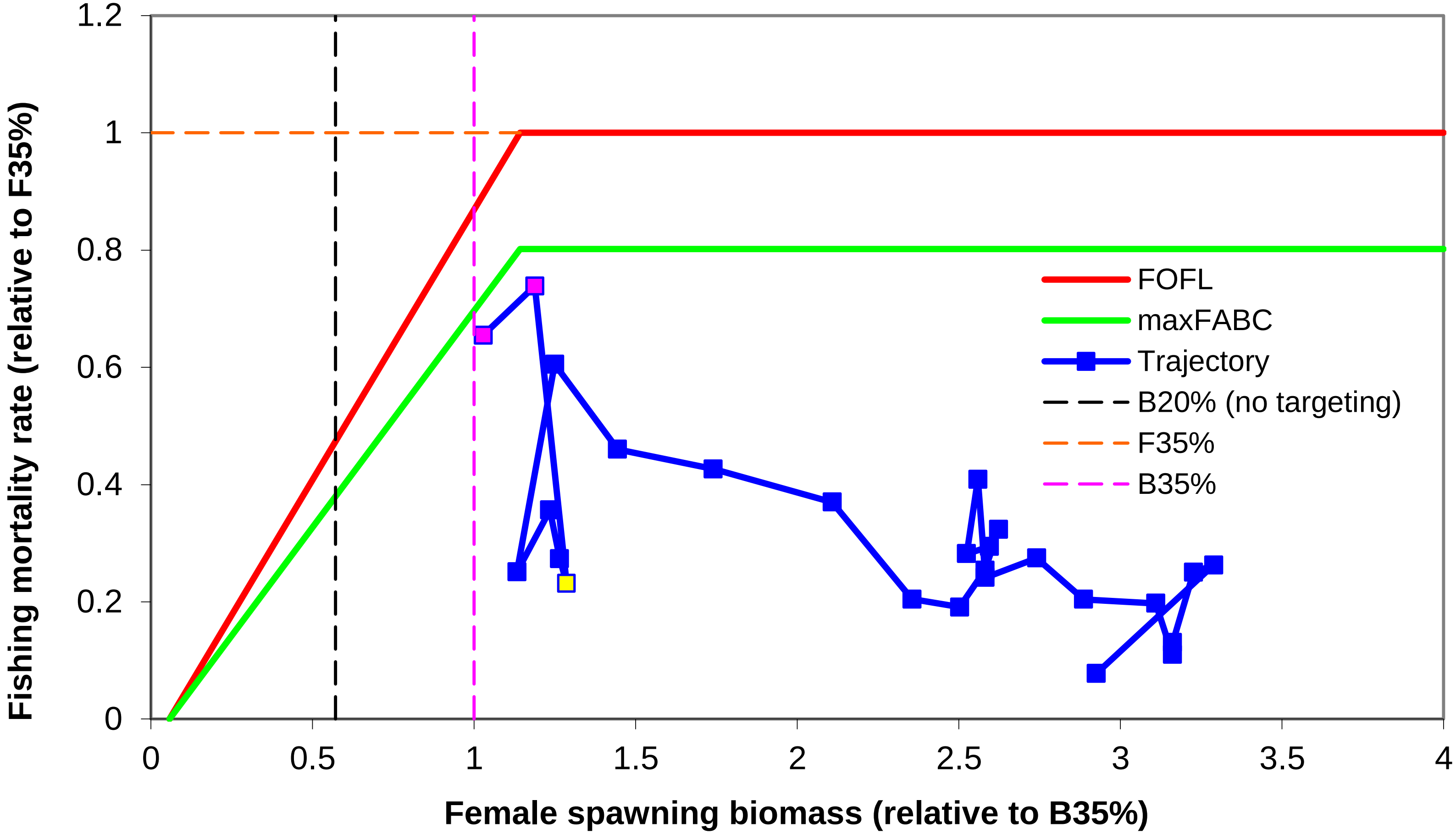
Future-year catch estimation



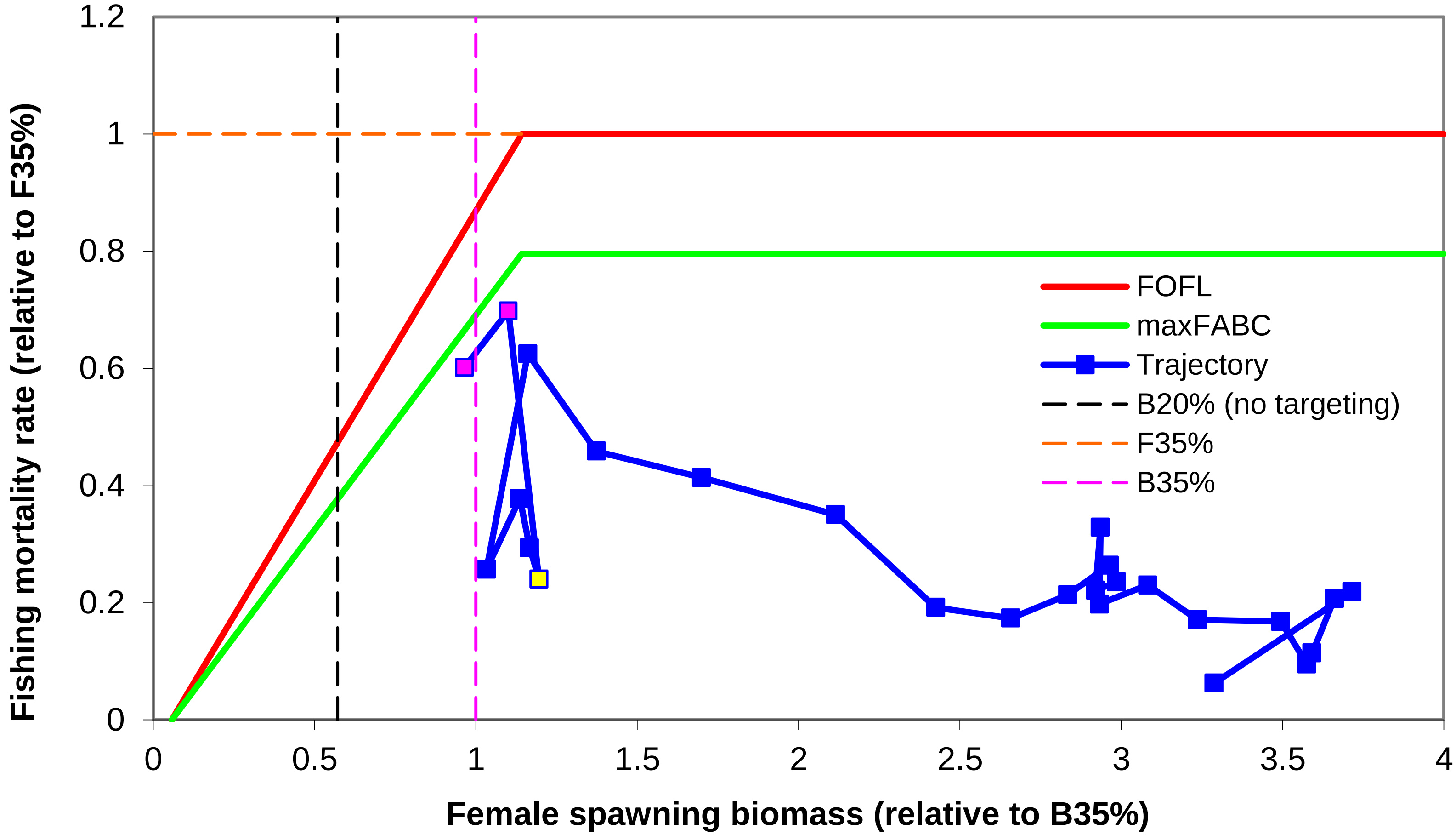
ABC recommendation and allocation

- Authors propose going with Tier 5 maximum permissible ABC (=17,600 t)
- But, the coauthor notes:
  - Area swept estimates of density are expanded over all habitat regardless of whether it is deemed trawlable or not
  - This approach has been critiqued by Cordue (2007) and more recently by CIE reviewers for non-target species in the AI
- SSL final rule will require an estimate of the proportion of biomass residing in Area 543
- Some alternatives:
  1. 1991-2014 average proportion from the survey (26.5%)
  2. Most recent proportion from the survey (24.6%)
  3. 1991-2014 average proportion from the random effects model (25.6%)
  4. Most recent proportion from the random effects model (26.3%)
- All of the above estimates are quite close to one another (mean=25.7%)
- To parallel the process used to set the overall ABC, it seems reasonable to estimate the biomass proportion in Area 543 by using the most recent estimate from the random effects model (26.3%)

Fishing mortality vs. spawning biomass (M2)



Fishing mortality vs. spawning biomass (M3)



Management reference points

Quantity	Model 1	Model 2	Model 3
B100%	n/a	127,000	121,000
B40%	n/a	50,800	48,400
B35%	n/a	44,500	42,400
B(2015)	68,900	52,800	46,600
B(2016)	68,900	45,700	40,900
B(2015)/B100%	n/a	0.42	0.38
B(2016)/B100%	n/a	0.36	0.34
F40%	n/a	0.54	0.63
F35%	n/a	0.66	0.79
maxFABC(2015)	0.26	0.54	0.61
maxFABC(2016)	0.26	0.48	0.53
maxABC(2015)	17,600	33,400	29,300
maxABC(2016)	17,600	26,300	23,500
FOFL(2015)	0.34	0.66	0.76
FOFL(2016)	0.34	0.59	0.66
OFL(2015)	23,400	40,000	34,900
OFL(2016)	23,400	32,600	29,200
Pr(maxABC(2015)>truOFL(2015))	n/a	0.13	0.12
Pr(maxABC(2016)>truOFL(2016))	n/a	0.38	0.38
Pr(B(2015)<B20%)	n/a	0.00	0.00
Pr(B(2016)<B20%)	n/a	0.00	0.00
Pr(B(2017)<B20%)	n/a	0.00	0.00
Pr(B(2018)<B20%)	n/a	0.00	0.00
Pr(B(2019)<B20%)	n/a	0.00	0.00

Research priorities

- At this point, the most critical needs pertain to trawl survey catchability and selectivity, specifically:
  1. To understand the factors determining these characteristics
  2. To understand whether/how these characteristics change over time
  3. To obtain accurate estimates of these characteristics
- Ageing also continues to be an issue, as the assessment models consistently estimate a positive ageing bias
- Longer-term research needs include improved understanding of
  1. Ecology of Pacific cod in the AI, including spatial dynamics, trophic and other interspecific relationships, and the relationship between climate and recruitment
  2. Ecology of species taken as bycatch in the Pacific cod fisheries, including estimation of biomass, carrying capacity, and resilience
  3. Ecology of species that interact with Pacific cod, including estimation of interaction strengths, biomass, carrying capacity, and resilience